LOCOMOTIVE TEXT

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FOR

ENGINEERS
and FIREMEN

A COMPLETE TREATISE ON THE LOCOMOTIVE AND ELECTRIC HEADLIGHT

EDITED AND PUBLISHED
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PREFACE.

This Text for Engineers and Firemen was prepared by practical engineers, who have had years of experience in road service, in addition to many years of experience in the instruction of enginemen. Each subject on the Locomotive and its attachments is explained in plain, comprehensive language, and in such a manner that it can be readily understood by the inexperienced engineman as well as by those who are more advanced in the service. It is unlike all other instruction books of this class, which contain a large amount of matter pertaining to shop tools and shop practices, which are of no particular value to the engineman. All mathematical problems, mechanical calculations, shop tools and testing appliances, methods used in shop practice and the science of combustion have been omitted, with a view of assisting the engineman to become more proficient in the care and management of the locomotive. While we can fully appreciate the benefits of a knowledge of higher mechanics and a scientific knowledge of combustion, we do not believe that they should be confounded with practical locomotive running and management.

The Authors have aimed to treat each subject briefly and thoroughly, and in such a manner that they may be understood by the beginners, as well as by the experienced engineman.

FRED MCARDLE,
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PART I.

LOCOMOTIVE FIRING.

The locomotive fireman should study the fundamental principles of firing, which will make him efficient and give him the necessary skill and knowledge to make the fuel which is applied to the furnace burn so evenly and hotly that it will evaporate into steam as much water as is possible in locomotive service. In other words, with skillful firing, the fuel consumed will perform its maximum duty. There are other qualifications which make the fireman a valuable man. The ability, however, to keep up steam to its maximum pressure is the most essential one, and is the first consideration for a man holding this position.

While not absolutely essential, a knowledge of the science of combustion will often enable the fireman to overcome many difficulties in handling the various classes of fuel. The skillful fireman is one who has the ability and knowledge to fire a locomotive and to analyze by sight the various grades of coal; that is, his knowledge of firing will enable him to determine the best method of handling the particular grade of coal furnished the locomotive to the best advantage. The main object at all times is to maintain a maximum pressure to meet the demands made upon the locomotive in the various classes of service. Though a man may become a skillful fireman

without a scientific knowledge of combustion, there is one mental qualification which he must possess in order to be successful; that is, good judgment, which is an aid to success in every calling, and especially in railroad work. In making a trip over a division a locomotive pulling a heavy train must meet so many varying conditions in the demand for steam that the successful fireman must exercise the best of judgment; or, in other words, he must have his fire in the right condition to meet the demands made upon the locomotive. The preparation of a fire before starting upon a trip is one of the most essential parts of his duties. In fact, the success of a trip depends largely upon the proper building up of the fire before leaving the terminal. Hence the necessity of the fireman arriving at his engine in ample time to build the fire up gradually before the schedule or marked leaving time of the train. There is no imperative rule that can be recommended, by reason of varying conditions under which the start is made, these conditions governing to a great extent the kind of fire necessary to be on the grates before starting. It depends wholly on whether or not the train will start out of the terminal upon an ascending, level or descending grade. In addition to building a fire up gradually, the fireman must see that the grates are loose, clinkers and ashes removed, and the ash pan clean before starting from the enginehouse track. The coal must be broken into suitable size before being placed in the fire-box, never losing sight of the rule that the coal for the next fire should be prepared immediately after putting in a fire.

Placing Coal in the Fire-Box. The following illustrations show the proper methods of applying the fuel to the fire-box, in addition to showing the disadvantages of incorrect methods of firing. Fig. 1 shows the long, narrow fire-box. The lines indicate how the coal should

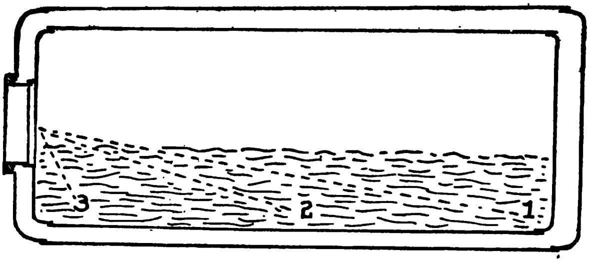


Fig. 1.

be placed. The deep line (1) shows the first shovelful of coal to be scattered evenly from the front part of the box back to one-third of the distance; center line (2) shows the second shovelful, to be scattered from a point reached by the first shovelful back to cover two-thirds the length of the box. Lower line (3) shows the third shovelful scattered through the rear portion of the box. All should be placed evenly on one side of the fire-box, leaving on the opposite side a bright, incandescent fire, which consumes the gases liberated from the fresh fuel. After the fuel has become ignited and is burning bright, the next fire will be placed along the opposite side of the box in the same manner as previously described.

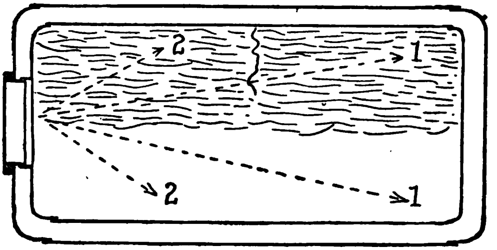


Fig. 2.

Fig. 2 shows the short fire-box, firing with the one-shovel system. This figure indicates how the coal should

be applied at frequent intervals, one shovel at a time. This method is especially practical on small passenger, freight and yard engines. The same system may be adopted with the wide fire-box, using the necessary number of shovels of coal to cover the fire evenly on each side of the box alternately. The action of the draft on the fire usually carries enough fuel to the center of the grates so that it will not be necessary to apply fresh fuel in the center of the fire-box except in the event of thin spots or holes being made through the center of the fire.

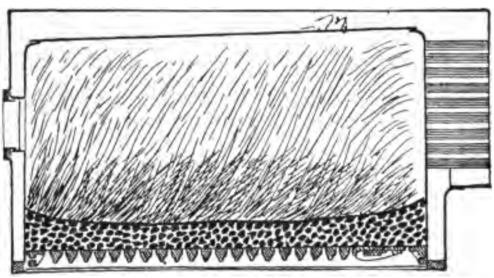


Fig 3

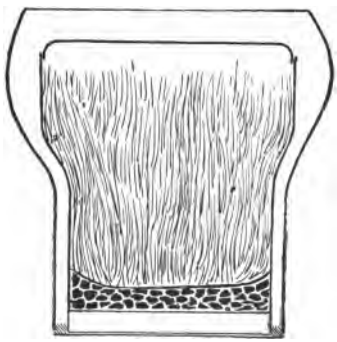


Fig. 4
PERFECT.

Figs. 3 and 4 show side and end views of the fire in a nearly perfect condition. It will be noted that the fire

is slightly heavier at the sides and ends of the fire-box than in the center, and it should be kept in this condition, as there is more air admitted at the sides and ends of the fire-box than through the center. The heavier fire protects the sheets from coming in contact with the cold air entering through the grates.

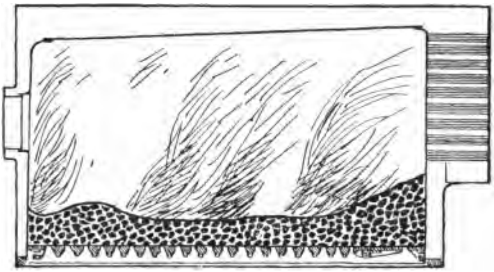


Fig. 5.

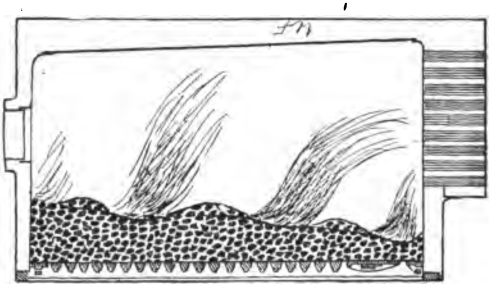


Fig. 6.

Figs. 5 and 6 show the result of heavy or uneven firing, or what is termed "banked." It will be seen in Fig. 5 that the fuel is banked against the flue sheet and also banked ahead of the back sheet. This method destroys a large portion of the heating surface, and, in addition to destroying the steaming qualifications of the engine, causes clinkers to form beneath the unconsumed fuel. Fig. 6 shows heavy and short firing, indicating that

the fuel has not been thrown far enough ahead to reach the front end of the fire-box, allowing the fire to become very thin next to the flue sheet. This permits cold air to enter the fire-box and flues, causing them to contract and leak. The heavy fire extending from the fire-door nearly to the front end of the box does not allow the necessary amount of air to pass through the fire and mix with the gases liberated from the fuel, and therefore results in improper combustion in all parts of the fire-box. The grates should be shaken often enough to keep them clear from clinkers and ashes. They should be moved with short, quick jerks. The slow moving of the grates to full length of the throw does not have the effect of breaking the clinkers, that is accomplished by moving as above described. The purpose of the grates is to provide a means of breaking the clinkers, so that they will fall into the ash pan, leaving the grates open for the admission of air.

There are circumstances and conditions in which the methods, as previously described, would not be a success by reason of the various classes of coal used and certain items requiring special attention and firing. In a general way, however, the methods herein described are those of the most successful fireman. A man who does the work of firing a locomotive with skill and intelligence is one of the company's most valuable men, as he is in position to save more money through the economical use of fuel than all other employes.

DUTIES OF ENGINEMEN BEFORE LEAVING TERMINAL.

Enginemen should arrive at the roundhouse in ample time to prepare the engine for the trip. After ascertaining what engine is assigned to the run they should examine the bulletin board, on which is posted a list of all

important and special notices. Their first duty on arriving at the engine is to ascertain the amount of water in the boiler and the condition of the fire. There should not be less than two gauges of water in the boiler, and a light, even fire all over the grates, burning bright and free from clinkers and ashes. There should be no leaks in the fire-box, the flues should be clean and dry, and none of them stopped up.

After procuring the necessary tools and supplies, the next duty of the fireman is to prepare the fire for starting the engine on its run, see that the grates are in proper condition, examine the ash pan, and make sure that there is a full supply of water, coal and sand.

Preparing the Fire. Always aim to keep a bright, level fire burning all over the grates by adding a small amount of coal at frequent intervals, evenly placed on all parts of the grates, and a good, solid fire burning in readiness to leave on the scheduled or marked leaving time of the train.

If it is found that the fire has been banked by the roundhouse man, or that the fire is clinkered (Figs. 5 and 6), the clinkers should be removed and live coals spread over the entire grate surface, and the grate bars should be loose and straight.

Avoid Forcing Fire. At least thirty minutes should be taken before departure of train to build up the fire gradually, without forcing, which has a tendency to keep the fire clean, admitting enough air to the fire-box in proportion to the fuel applied, preventing black smoke and aiding materially in keeping the fire free from clinkers and ashes.

Condition of Grates. It is very important that the grates should be in proper condition, for upon this depends the successful firing of the engine. Grates in good condition will prevent live coals from filling the ash

pan and dropping upon the ties, bridges and other places, causing danger from fire.

STARTING FROM TERMINAL.

Before starting from the terminal the fireman should always compare the time of his watch with that of the engineman's; he should insist upon seeing all orders and special instructions and should read all bulletins relating to train movements. It is part of the duty of all train and engine employes to understand and obey all bulletin instructions issued for their information and guidance.

The engineman may overlook the execution of an order, which would not occur should the fireman remind him of such orders at the proper time. It is also necessary that he inform himself where an order is to become effective, in order that the fire may be handled accordingly.

Firing After the Start. After the train has started the fuel should be applied frequently and in small quantities, evenly distributed over the fire, first on one side of the fire-box, then on the other. (Figs. 1 and 2.) Care should always be taken that the fire is kept at a bright, incandescent heat on one side of the fire-box, to consume the gases which are liberated from the fresh fuel placed on the opposite side.

Firing on Each Side of Fire-Box Alternately. The practice of firing on each side of the fire-box alternately is an aid to combustion. Spreading fresh fuel over the entire fire reduces the temperature of the fire-box below ignition point. The heat of the fire is sufficient to liberate the gases from the fuel, but is of too low a temperature to cause combustion of the gases, allowing them to pass into the flues unconsumed and out of the smokestack in the form of black smoke.

In addition to this, the fuel is consumed more rapidly

along the sides and in the corners of the fire-box than in the center. "Short firing," an expression common among firemen, means that the grates are not evenly covered the entire length of the fire-box. (Fig. 6.)

Before the Stop. When a stop is to be made, the last fire before reaching the stop should be put in far enough from the station to give time for the gases to burn out of the coal before the throttle is closed.

If the injector is to be used after the throttle has been shut off there should be a good, bright fire in the fire-box, and it should be kept bright by adding small amounts of coal and using the blower lightly until the boiler is filled to the proper level, in order that a uniform temperature and pressure may be maintained and danger of leaks in flues and fire-box lessened.

Keep Down the Smoke. The prevention of smoke from a locomotive is of the utmost importance when passing through tunnels, under station sheds, and through municipalities where the "smoke nuisance" has caused legislation to be enacted providing for fines against railroads on this account.

Building up the fire without the necessary care results in the formation of clinkers and in time causes the boiler to leak. Forcing the fire with heavy charges of fresh fuel does not give the gases a chance to be consumed, reduces the temperature below ignition point, forms black smoke and wastes fuel.

Bituminous Coal—How to Prepare. When bituminous coal is used, it should be broken into lumps three or four inches in diameter. The advantage gained is that a greater surface of the coal is exposed to the fire, allowing a more rapid liberation of the gases, which, combined with the gases admitted to the fire from the atmosphere, produces more rapid combustion.

Using Fine or Slack Coal. Fine or slack coal should

be wet down to prevent dust. In addition, moisture gives it a body, cementing the small particles together and retarding the liberation of the gases, which would be freed more rapidly than consumed if the slack coal were dry.

Before the engine is shut off for a stop, the fire should be burned down to prevent the engine from "blowing off" or emitting black smoke. This prevents a waste of steam and consequently saves fuel.

Before the train starts again the fire should be built up, in order to have a good, solid fire burning bright, in addition to having a full head of steam.

On a Siding—Care of Fire and Water. When a train is delayed on a siding the fire should be kept bright and dampers down, in order to maintain an even temperature in the fire-box. The water should also be maintained at the proper level in the boiler.

Advantage of Good Fire and Water Supply. The advantage of having a good fire and a good supply of water in the boiler before starting is that the train can be put under headway without reducing the steam pressure or forcing the fire. A good supply of water in the boiler will eliminate the necessity of putting the injector to work until the fire has been built up, thereby preventing a reduction of the fire-box temperature. The fireman should keep himself posted in regard to all trains he has to meet or pass, as it is required by the company, and with this knowledge the engine can be fired more economically and to better advantage.

Other Duties of the Fireman. The fireman should learn as soon as possible to operate the injectors, lubricator, engineer's brake-valve, reverse lever and throttle. He should learn how to work the injectors in order to become competent to regulate the supply of water in the boiler.

It is also important that the fireman learn to use the throttle, reverse lever and air-brake, as he is often requested by the engineman to move the engine. He should know and keep on the lookout for all fixed signals, in addition to knowing how to read the signals accurately when given by the trainmen. He must watch the ash pan, grates, water level, and, in fact, make himself generally useful about the engine.

The Handhold Plate and Hopper. If the handhold plate and hopper are not closed tightly it will interfere with the steaming of the engine, by destroying the smoke-box vacuum. In addition to this the smoke-box will become overheated through cinders in it catching fire, and when it cools off will warp and crack.

Honeycombed Flues. If the flues should become honeycombed by clinkers from foreign matter in the fuel, when on the road, they should be cleaned off with a rod or ash hoe. Honeycombing or clinkering of the flues destroys the heating surface, thus causing poor steaming of the engine.

Disconnected Grates While on the Road. If a section of the grates should become disconnected it will allow holes to form in the fire, which would admit too much cold air. This reduces the temperature of the fire-box below ignition point, causing poor steaming of the engine. The ash pan also would become filled with live coals, endangering all combustible materials over which the engine might pass. The grates should be connected at once, if possible, but if this cannot be done, they should be straightened, and the disconnected portion used as a "dead grate."

Clinkered or Dirty Fire. When the fire in an engine becomes clinkered or dirty, it causes a poor steaming engine and leaky flues, and also prevents the necessary amount of air for combustion from entering the fire-box.

In order to obtain best results, the grates should be kept loose and free from clinkers, the fire as light as practicable, the fuel to be applied often and in small quantities. A low, level fire (Fig. 3) allows the necessary amount of air to pass through the grates, giving more perfect combustion, not obtainable with a heavy fire, as shown in Figs. 5 and 6.

Necessity of Admitting Air to the Fire. To consume one pound of coal about two hundred and sixty cubic feet, or thirty pounds of air, is required. This fact in itself shows the importance of keeping a low, level fire in order to admit the required amount of air for proper combustion. When dense volumes of black smoke are emitted from the stack of an engine it indicates either a dirty, clinkered fire, too heavy a fire, or improper firing, all of which cause improper combustion and waste of fuel.

Arrival at Terminal. When the engine arrives at the terminal the engineman should see that the fire is in good condition, that there is plenty of water in the boiler, the dampers down and, if at night, they should extinguish all signal lamps except those necessary for protection on the rear of the tender.

Principles of Combustion. Combustion is the uniting of oxygen with combustible matter that has been heated to the point of ignition. Oxygen is obtained from the air, but is only one of the universal gases.

LAWS OF COMBUSTION.

A knowledge of the laws of combustion is valuable to a fireman because he can save both fuel and labor by putting this knowledge into use. The chief cause of imperfect combustion is an insufficient amount of air being admitted through the fire, due to heavy firing and the accumulation of ashes and clinkers on the grates. The proper amount of air can be admitted to the fire by

keeping the fire and ash pan clean and by correct regulation of the dampers.

The fireman should keep a close watch on the fire for bright spots needing more coal. Under ordinary conditions from seven to ten pounds of water can be evaporated by one pound of coal, but this depends, to a great extent, upon the grade of fuel used.

LARGE GRATE SURFACE.

A large grate surface is advantageous, as it does not require so heavy a fire as when the grate surface is narrow, and greater economy is possible with an inferior grade of coal. Grates should be shaken only when necessary to keep the fire clean and in good condition. If the ash pan is allowed to become filled it shuts off the draft, warps and burns the ash pan, grates and grate bars.

GRADES AND STATIONS.

Every engineman should know the grades and the locations of all stations on the division on which he is employed. This knowledge will enable the fireman to prepare the fire accordingly, have it in good condition at the foot of grades and at stops, and will prevent black smoke and "blowing off." When steam escapes from the safety-valve it represents a waste of fuel and water. About fifteen pounds of coal is wasted each minute that the safety-valve is open.

THE LOCOMOTIVE BOILER.

The locomotive boiler is cylindrical in form and has a rectangular shaped fire-box at one end and a smoke-box at the other, with flues running through the cylindrical part. As the heat from the fire-box passes through them, it affords the greatest possible heating surface in contact with the water. (Fig. 7.)

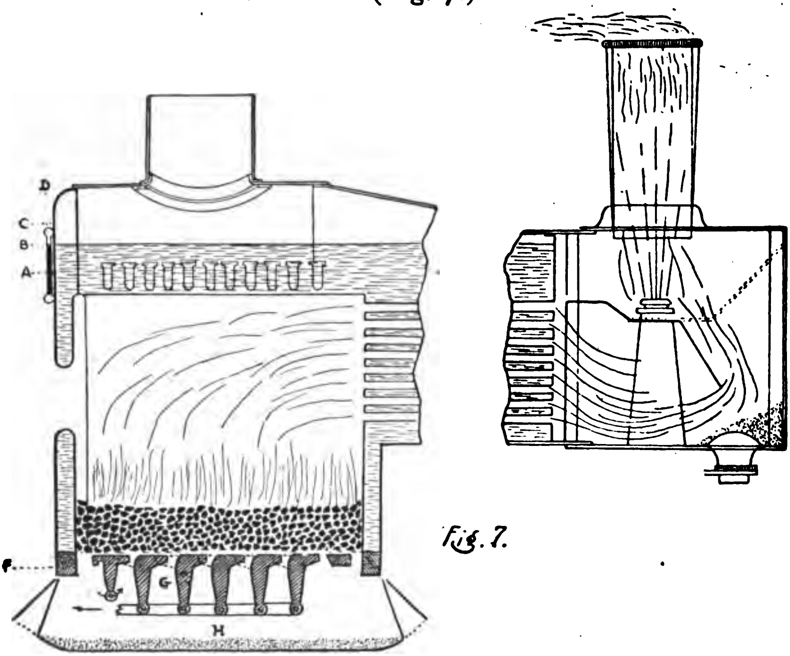


Fig. 7.

The Locomotive Fire-Box. The modern fire-box of a locomotive is rectangular in shape (Fig. 9), and consists of side sheets (E), crown-sheet (U), back sheet (C) and flue sheet (Y). The fire-box is subjected to a crushing strain. The sheets of the fire-box are supported by means of stay-bolts (w), screwed through the outside

and inside sheets and riveted. Hollow stay-bolts (Fig. 10) are used so that a broken bolt can be detected by escaping steam from the drill hole in the bolt for that purpose. The crown-sheet is supported by means of the crown-bars and radial stays.

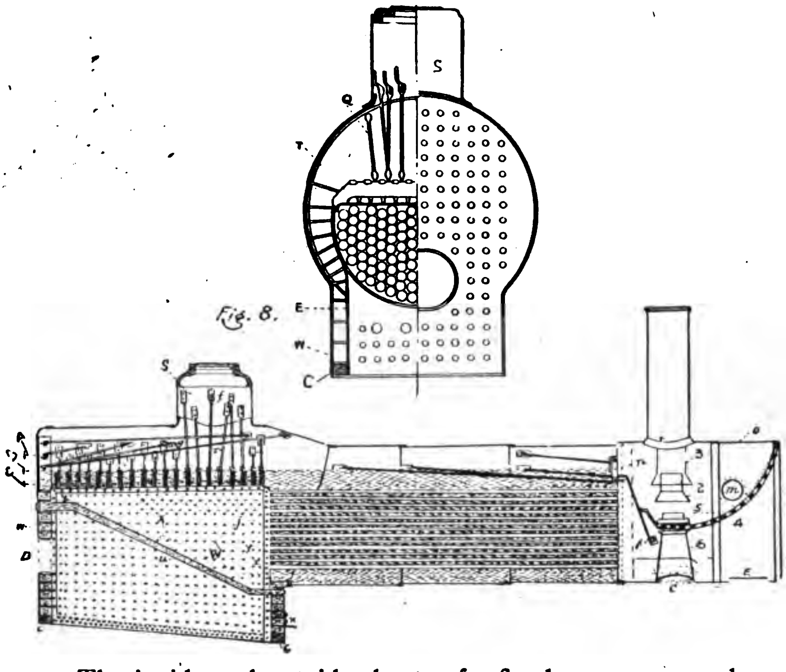


Fig. 8.

The inside and outside sheets of a fire-box are secured at the bottom by being riveted to a foundation ring, commonly called the mud ring (C, Fig. 8), showing the side view and end view. The attachments below the mud ring are the grates, ash pan, lever for shaking the grates and the dump drop grate.

Crown-Bars. Crown-bars are those that support the crown-sheet (T, Fig. 8). Radial stays are the supports which extend from the crown-sheet through the outside

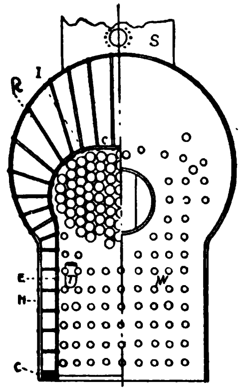
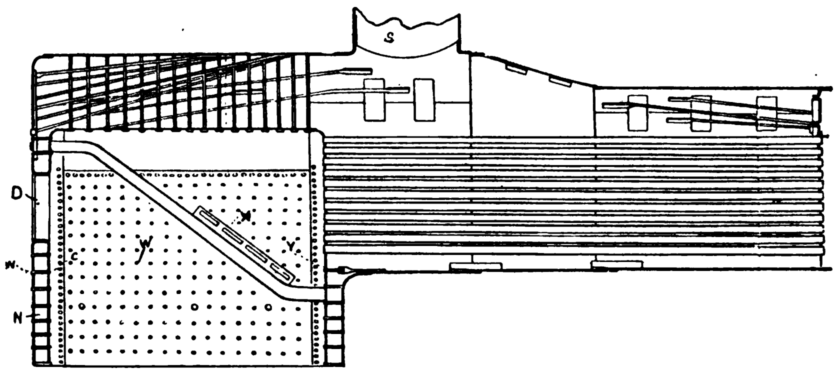


Fig. 9.



shell of the boiler (R, Fig. 9). Sling stays are supports extending from the crown-bars to the outside shell of the boiler (Q, Fig. 8).

The most objectionable feature to the use of crown-bars is the difficulty of keeping them clean, due to the fact that mud collects between the crown-sheet and bars, thus endangering the crown-sheet by overheating. Radial stays are considered superior to crown-bars, as

they can be more easily kept clean, more economically repaired and allow better circulation of the water.

Circulation of the Boiler. This is a term applied to the movement of water in the boiler when heated. The water, coming in contact with the heated fire-box and flues, is converted into steam, rises to the top and fresh water takes its place, thus causing the water to move or "circulate." To obtain the best results a boiler must have good circulation, and it must be clean and free from corrosion, scales, mud, etc.

Wagon Top Boiler, Steam Dome, etc. A wagon top boiler is one that has a fire-box end much larger than the cylindrical part (Figs. 7 and 8), in order to provide more dry steam space. Steam domes insure dry steam as well as giving space for the throttle valve and throttle levers.

Every locomotive has an extension called the smoke-box at the front end of the boiler (Fig. 8), in which are located the draft appliances, and where the cinders forced through the flues are collected after being caught by the netting.

BRICK ARCHES.

A locomotive fire-box is usually equipped with an arch, which insures more perfect combustion by retaining the gases and thus allowing more time for their ignition. For the same reason it is an aid in preventing black smoke. It also prevents the direct admission of cold air to the flues when the fire-door is open, or when there are thin spots in the fire.

A hollow arch is one with passages which are open to the atmosphere by tubes passing through the sheets of the fire-box (Fig. 9). The advantage of the hollow arch is that it deflects air over the fire, mixing the oxygen with the gases, and thus aiding combustion.

LEAKS IN THE FIRE-BOX.

Sudden changes of temperature in the fire-box cause the flues to leak, due to the expansion and contraction of the sheets. If a leak occurs in a tube or the fire-box, the fireman should keep a full head of steam, if possible, and a bright fire burning constantly. If the leaks are in the lower part of the side or end sheets, the fire should be banked at the place of leakage to prevent the water and steam from deadening too much of the fire. If a flue is leaking it should be plugged if possible. The flues and flue sheets are the parts of the boiler most sensitive to cold air.

ABUSE OF BOILER.

Chief among the abuses of the boiler are, allowing the pressure to drop back and then generating steam quickly by the use of the blower; overpumping the boiler, thereby reducing the steam pressure; improper firing, and sudden changes in the temperature of the fire-box.

Sudden changes in fire-box temperature cause a sudden and continuous contraction and expansion of the flues and sheets. This contraction and expansion cause the sheets to crack and the flues to leak.

CARE OF THE BOILER.

Water should never be put on a sheet that has become red hot, as water is likely to crack the sheet and cause it to be forced off the stay-bolts. If mud or scales accumulate on the crown-sheet, those parts of the sheet where the mud or scales are located will become overheated.

The narrow space between the inside and outside of the fire-box is known as the leg of the boiler (n, Fig. 9). The most important features insuring the safety

of the boiler are frequent inspections, replacing the broken stay-bolts (Fig. 10), and washing out the boiler. The length of time that a boiler should be run before being washed out depends largely on the condition of

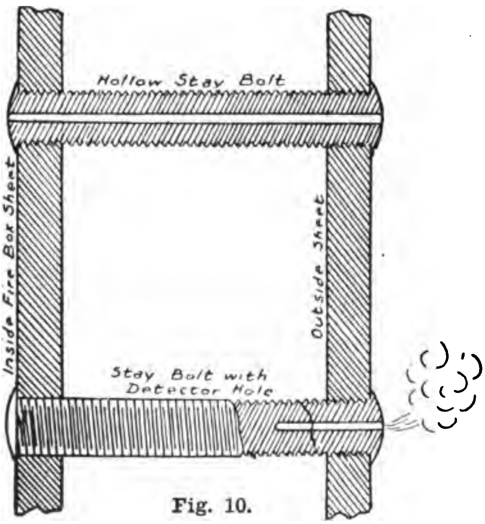


Fig. 10.

the water and the class of service. The average miles run between washouts are usually from six hundred to one thousand.

The boiler check is usually placed near the front end of the boiler to introduce the water at as great a distance as possible from the fire-box. The advantage thus gained is that it permits the water to become heated before coming in contact with the fire-box, and also tends to bring about a better circulation in the boiler.

DRAFT APPLIANCES.

The draft appliances of a locomotive (Fig. 11) include diaphragm (1), petticoat-pipe (2), sleeve (3), netting (4), exhaust nozzle (5) and exhaust stand (6).

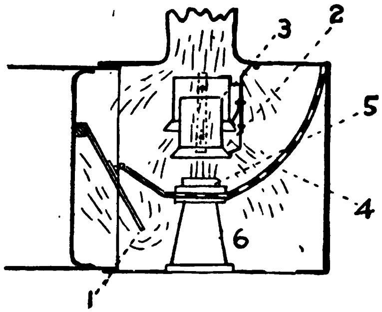


Fig. 11.

The diaphragm is a sheet of steel fastened at an angle just above the top of the boiler tubes, which deflects the smoke and cinders towards the bottom of the smoke-box. Attached to the stationary portion of the diaphragm is another section, hinged in modern locomotives, which when raised or lowered governs the draft through the tubes. Raising the diaphragm decreases the draft through the lower and increases the draft through the upper flues.

The petticoat-pipe (2), which is cylindrical in shape, is set directly over the exhaust nozzle (5), and has a second tube of larger diameter, called a sleeve (3), above, so as to telescope with it. They are in direct line with the stack and act as a guide for the steam from the exhaust nozzle passing out of the stack.

Raising the sleeve and lowering the petticoat-pipe decreases the draft on the fire; raising the petticoat-pipe

and lowering the sleeve increases the draft. (Fig. 11.) If a fire burns more intensely at the front end of the fire-box it indicates that the draft is greater through the lower flues; if the fire burns stronger at the fire-box door it shows that the draft is greater through the upper flues.

The netting (4, Fig. 11) is a steel screen fastened to the smoke-box to prevent large cinders from passing out of the stack. The smoke, gases and small cinders passing from the flues are deflected downward by the diaphragm, then pass through the netting, which prevents the large cinders from escaping and deposits them in the bottom of the smoke-box, (Fig. 7). The cinders are finally forced out of the stack, together with the smoke and gases, after they have been broken into small pieces against the netting.

The exhaust from the cylinders converges in the nozzle stand 6, and to the top of this the nozzle is attached by means of bolts or set-screws. The nozzle guides the exhaust steam into the petticoat-pipe, sleeve and stack. The smaller the size of the nozzle the sharper the draft on the fire; the larger the nozzle the less keen will be the draft.

Adjusting the Petticoat-Pipe. By increasing the space between the nozzle and the petticoat-pipe and between the base of the stack and the sleeve, more space is provided for the gases to pass from the front end, and by decreasing the space the draft decreases accordingly. When the exhaust is strongest on one side of the stack, it indicates that the exhaust stand, petticoat-pipe, sleeve or stack is out of line. (Fig. 8.)

"Red Fire." If, upon opening the fire-door, the fireman discovers what is commonly known as a "red fire," it indicates that the grates are probably clogged with clinkers and ashes. Another indication of the clogging

of the grates is the pull on the fire-door when opened. In addition to the clogging of the grates and derangement of the draft appliances, leaking steam pipes or clogged netting will cause the fire to look red. A leaky steam-pipe or a leaky exhaust stand gasket will cause the engine to steam badly. The escaping steam entering the smoke-box occupies the space that should be supplied with air from the fire-box.

The Blower. The blower when opened allows a jet of steam to pass to the front end and out of the stack, creating a partial vacuum in the smoke-box and causing a draft on the fire. Care should be taken not to give the fire-door too great an opening when using the blower whether the engine is drifting or standing, as this allows cold air to strike the flues and side sheets, causing them to leak.

HOW THE DRAFT IS CREATED.

Exhaust steam creates a draft on the fire by forming a partial vacuum in the smoke-box. The air from the fire-box is drawn through the flues, creating a draft on the fire, and in turn fresh air is forced by atmospheric pressure through the grates to supply the fire.

The drumming noise heard when the engine is shut off is caused by a succession of explosions of gases in the fire-box and indicates a clean fire. While this causes a noise that is very annoying it does not signify danger, and can be avoided by closing the dampers or opening the fire-door.

STEAM-GAUGE INDICATIONS.

The pressure indicated by the steam-gauge means the pounds per square inch above the atmospheric pressure. By atmospheric pressure is meant the weight of

the atmosphere which surrounds the earth. Atmospheric pressure is figured at 14 7-10 pounds per square inch at sea level.

STEAM GENERATION.

Steam is the source of power of the locomotive. It is an invisible gas generated by heating water above the boiling point. The water coming in contact with the heated sheets of the boiler rises in the form of bubbles to the top, where they explode in the form of steam.

Steam Temperature. Water boils at 212° Fahrenheit, when subjected to atmospheric pressure only. When the pressure of the steam is 200 pounds the temperature is 380° Fahrenheit.

OIL-BURNING ENGINE.

The Fire-Box. Oil-burning locomotives are coming into more general use each year, especially in sections of the country where the use of oil for fuel is more economical than coal. The growing scarcity of the supply of coal in certain sections is also tending toward the increased use of oil for fuel. A coal-burning engine can be converted into an oil-burner with only a few minor changes in the fire-box attachments.

The oil is carried in a specially arranged compartment in the tank, usually above the water. The fire-box of the engine is arranged for the use of oil as fuel by placing a wall of fire-brick around the sides and front to protect the sheets. Brick which is affected by extreme heat is used in preference to heat-resisting brick, as the former will, after being superheated, bind better when cooled and so resist the hard usage resulting from the vibrations and shocks caused by the movements of the engine.

The methods of using oil as fuel for a locomotive have been advancing steadily. First there was the Hearth Furnace, in which the liquid was thinly distributed in pans and burned; next came the Gas Furnace, in which the oil was transformed into gas before being fed to the fire-box; while with the present system an atomizer is used, by which the oil is sprayed into the fire-box.

The use of oil as fuel is not new, dating back about fifty years, when it was used under the boilers in factories in foreign countries. Petroleum, which is found in many parts of the United States, has been proved to be far superior to coal as fuel for locomotives. It is smokeless when handled properly, and is free from dirt; its supply for the furnace can be regulated almost in a moment; it does not require stoking; takes less room than coal for

storage purposes, and gives off a hotter flame. No sparks are thrown out from the stack, which would cause danger of fire. The cost of handling oil as fuel is much less than that of coal. Increase of wear over coal to the fire-box is the feature most objectionable to its use.

Converting a Coal-Burner to an Oil-Burner. When a coal-burning engine is converted into an oil-burner the first change to be made is to remove the grates and their connections and change the ash pan. A casting is placed inside the ash pan and fastened to the sides and near the top of the pan. This acts as a support for the brick work inside the fire-box. It is bored out so as to permit air in proper quantities to enter the fire-box for proper combustion. The brick arch is built as low as possible in order to protect the crown-sheet, crown-bolts and seams from the excessive heat of the oil flames. The oil-burner or atomizer is secured to the bottom of the mud ring central with the fire-box and at such an angle that when the spray is emitted it will strike underneath the arch. (Figs. 12 and 13.)

The oil tank on the engine tender must be provided with a heater coil for the purpose of keeping the oil at the proper temperature in cold weather. Where heavy oil is used an air pressure of about five pounds is maintained upon it in order to keep up the proper flow, unless the oil is heated by the coil or the weather.

Emergency Valve. To provide for emergencies, in case the engine becomes detached from the tender, the oil tank on the engine is provided with an automatic valve connected by means of a rope or chain with a spring key which passes through the upright rod of the valve, and is so arranged that the rope will pull the key out of the rod, causing the valve to close and shut off the supply of oil.

The Atomizer. The atomizer is the outlet for the oil

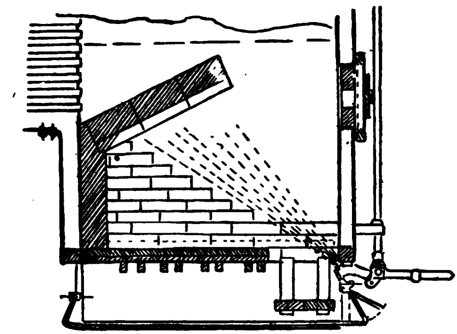


Fig. 12.

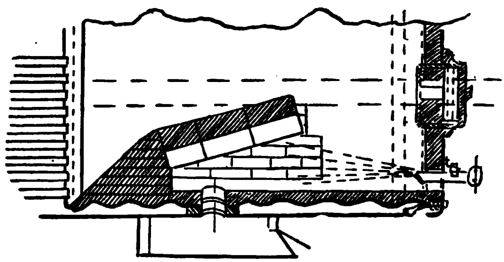


Fig. 13.

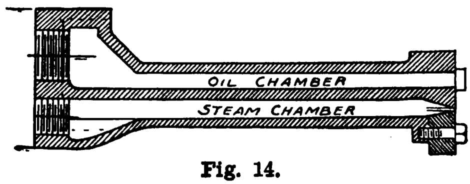


Fig. 14.

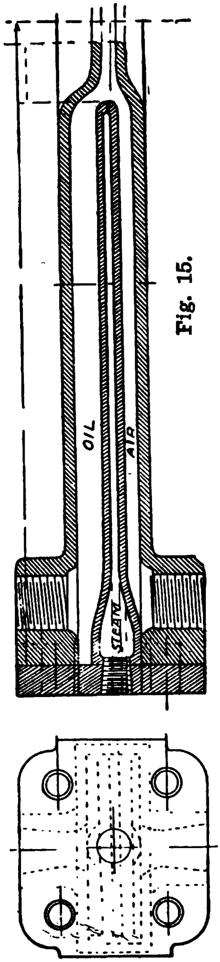


Fig. 15.

supply through which the oil is fed to the fire-box. It is generally about twelve inches in length, and is in some cases divided into two compartments lengthwise (Fig. 14), while in others it has three (Fig. 15). The dividing partitions are parallel with the top and bottom of the atomizer. In the first style mentioned the oil passes through the upper compartment and steam through the lower, so as to heat the oil when passing to the outlet. In the other style the oil passes through the top compartment, steam through the center and air through the lower, uniting at the end of the nozzle so that the oil enters the fire-box as a spray mixed with air. In both cases the fire-box is filled with flame.

The atomizer with two compartments is attached to the bottom of the mud ring (Fig. 12). In the other style the burner is located in the upper part of the brick portion of the fire-box (Fig. 13). In deep fire-boxes the atomizer is placed at the back end, as in this type of fire-box the draft is strongest at that point. For the same reason it is placed at the front end in shallow fire-boxes.

Firing Up. In firing up an oil-burning engine at the roundhouse a steam connection is made with the three-way cock on the smoke-box, acting as a blower and atomizer at the same time. A piece of oily, lighted waste is thrown into the fire-box ahead of the burner. After this the oil is started slightly, and the atomizer valve is opened enough to spray the oil that is flowing from the burner, which will ignite at once. The fire should be watched closely until steam begins to form in the boiler, when the supply of steam from the roundhouse can be cut off. Care must be taken not to use too much oil, as this would cause an explosion. Care must also be taken that the fire does not go out, as the oil would run down into the pit and possibly take fire.

To light the fire on an oil-burning engine after steam has been raised and the fire has gone out, open the front damper and put on the blower strong enough to cause the necessary draft; open the atomizer valve long enough to blow out all the condensed steam that may be in the steam-pipe or burner; then close the valve and place a piece of lighted waste in front of the burner and open the atomizer far enough to carry the sprayed oil to the lighted waste. After this open the regulator slowly; it must be known that the oil has taken fire, which can be determined by looking through the opening in the fire-box door.

If the oil has not ignited it will run down into the pan, and when it finally becomes ignited an explosion will result, which would destroy the arch and damage the pipe connections.

The hot bricks should not be depended upon to ignite the oil. If the oil were allowed to accumulate on them, an explosive gas would be generated, and when ignited would damage the walls and arch.

When an oil-burning engine is to be fired up and steam cannot be had for the purpose, wood may be used until a pressure of from ten to fifteen pounds is obtained. Care must be taken not to damage the brick-work in the fire-box, and that the walls are kept in good condition; if broken parts of the arch or wall are permitted to drop on to the floor of the fire-box they may interfere with the proper working of the burner.

Loss of steam pressure in an oil-burning engine can be regained within a short time, at least in a decidedly less time than with a coal-burner, but the operation is very injurious to the sheets of the fire-box. The rivets on the inside of the fire-box can in this way be easily burned off, as the fire caused by suddenly increasing the supply of oil is extremely hot.

Burners. The burners should be so adjusted that the oil will strike about the center of the front wall of the fire-box. If the oil drops to the pan it will cause black smoke and a poor steaming engine. The black smoke would also indicate that more oil was being admitted to the fire-box than was being consumed. Sometimes the burner becomes stopped up with sand from the oil or small particles of waste drawn into the air inlet. The steam jet can be taken out of the majority of burners and cleaned, without disturbing the latter, and the trouble easily overcome. The blower should be used only strong enough to keep the stack clear of smoke, as too great a blast from it will create too strong a draft through the fire-box, reducing the temperature and causing a waste of fuel.

STARTING ENGINE.

The fireman should be at his post a reasonable time before the engine is started. The firing valve should be opened just enough to make sure that the action of the exhaust will not cause the fire to go out, but not enough to cause a large amount of smoke. When the engine is hooked up the valves controlling the admission of oil should be regulated accordingly. When starting it is good practice to use the blower about one-half turn, which will help consume the smoke between the exhausts and assist in keeping the boiler hot. Too much smoke produces a coating of soot in the flues and, as soot is a non-conductor of heat, it can readily be seen that the effect would be to destroy the steaming qualities of the engine.

The amount of smoke emitted from the stack can be taken as a guide as to the frequency with which the flues must be sanded. If there is much smoke after the engine is started and the engine is to be "worked

hard" they should be sanded every ten or twelve miles. If the flues are kept clear, sanding is required only every thirty or fifty miles.

Leaving Stations. When leaving a station the fire should be kept burning brightly and strong enough to keep it from being extinguished, as the strong draft at the start may put the fire out and chill the fire-box. As little steam as possible should be used in the atomizer, but not reduced to an extent which would allow the fire to go out. The use of too much steam will reduce the temperature of the fire-box.

A good illustration of the working of the atomizer is the common little atomizer used for spraying perfume. Too much air forced through the pipe from the bulb will cause drops, instead of a spray, while insufficient air forced through will not spray the perfume at all.

If the fire back-lashes and smokes while the engine is working, the fireman should ease off on the fuel and use the dampers. When the engine is drifting the dampers should be closed to prevent cool air from being drawn into the fire-box. When the engine is steaming well and being worked at full capacity the fire should not make any more smoke than under ordinary conditions.

The engineer should inform the fireman of every contemplated move of the throttle previous to his making it, in order that he may operate the feed valve accordingly.

Color of Fire. The fire should have a bright ruddy color, and is produced by feeding the proper amount of oil, watching the regulating valve closely, and admitting the necessary amount of air.

Water mixed with oil affects the flame and requires the admission of a greater amount of oil.

Drafting. The drafting of oil-burning engines is the

same as in coal-burning locomotives. The draft in the stack can be regulated so as to distribute it equally throughout the flues, by adjusting the draft appliances. It is good practice to fasten the draft appliances rigidly after they are properly adjusted, so that they can be depended upon and the necessity of readjusting avoided.

Engine Drifting. While the engine is drifting down long grades the fire should be kept burning lightly and not permitted to get too low. It should not be shut off altogether, for the reason that it would reduce the temperature in the fire-box and cause the flues to leak. While switching, the fire should be kept about the same as when running.

Extinguishing the Fire. The fire should never be put out entirely unless the end of the run has been reached and the engine is to be given up, or when both enginemen are going to leave the engine, and then it should always be extinguished. To put out the fire, first close the stop-cock under the tank, allow the oil to be drawn from the pipe and burner, and then close the firing valve, atomizer and all dampers.

Obstructions in the Oil Line. If there are obstructions in the oil line, close the firing valve, open the cock between the heater line and the oil line, turning the cock on the boiler head to the heater line on, full. In this way all obstructions will be blown back into the tank. This may also be used as a substitute for heating the oil in the tank if the coil heater should fail to work properly.

FORCING THE FIRE.

Forcing the fire on an oil-burning engine will cause the flues and fire-box to leak. An even temperature or as even as practicable should always be maintained. To obtain the best results, the feed valve should be

opened sufficiently to make it certain that enough oil is being admitted to produce a good fire, but not enough to produce a volume of smoke. By watching the smoke emitted from the stack it can easily be seen whether combustion is good or not.

The flues should be cleaned out after leaving terminals or after engine has been standing for some time. This is done by the frequent use of sand in small quantities.

The frequent use of the blower is injurious to an oil-burning engine. It will draw cool air into the fire-box and flues and cause them to leak. It is most injurious to use the blower when a light smoke is being emitted from the stack, as such is an indication of a light fire.

SANDING THE FLUES.

To sand an engine properly, use about one quart of sand. After the engine has been brought to a fair rate of speed, close all the dampers, put the reverse lever in almost full stroke and open the throttle wide, permitting the sand to be forced in a thin stream from the funnel which is provided for that purpose and placed in the opening of the fire-box door. It travels through the flues to the smoke-box, where it can be removed in the same manner as the cinders under the netting in the coal-burning engine. In this way all gummy deposits and soot can be removed from the flues.

AT THE OIL STATION.

In approaching an oil station, care should be taken that no lamps or lights are burning on the tender when the stop is made. No lights should be brought closer than ten or fifteen feet from the supply tank, as the escaping gas from the oil is likely to cause an explosion

when it comes in contact with the flames of the lights.

The depth of oil in the tank should be measured either by the gauge or by a stick or rod, just as water is measured at the manhole, but never with the aid of a light. Before entering a tank which has been used for oil, either to clean out or to make repairs, care should be taken that it is thoroughly cleansed.

ADVANTAGES OF THE OIL-BURNING ENGINE.

To sum up the advantages of the oil-burning engine over the engine using coal, the following points are self-evident: The use of oil as a fuel means economy in handling; a reduction in the waste of fuel; no cinders to be handled or to annoy passengers; less waste of steam at safety-valve; less weight of fuel; economy of space for fuel; no sparks; no stoking; increased use of heat; engine can be turned and made ready for a new trip more quickly than with coal-burning fire-box; fire can be lighted instantly and lost steam pressure recovered more quickly; can be regulated instantly; a freer steaming is assured, and a maximum tonnage can be handled to better advantage.

THE ENGINE AND ELECTRIC HEADLIGHT.

PART II.

LOCOMOTIVE INJECTORS.

"As with all new inventions and improvements, great difficulty was experienced in obtaining a fair trial of the merits of the injector. In many cases the exaggerated claims of its advocates placed as many obstacles in its way as the severe and condemnatory criticism of its enemies. The advantages, however, of the new method of boiler feeding, the simplicity and efficiency of the apparatus, and the comparatively small cost of installation and maintenance, were soon appreciated by steam users, and to-day the injector is among the most popular boiler feeding appliances in use. It is, without doubt, better than all other devices heretofore used for feeding boilers, and is the best that can be used, for the reason that it is the simplest and most ingenious. Hundreds of thousands of injectors are in use to-day, and there is hardly a locomotive running in any part of the world which is not provided with at least one injector. Many steam vessels and stationary plants are equipped with them as boiler feeders. It is therefore of the utmost importance that every fireman and engineman should be thoroughly familiar with both the details of their construction and their use.

What Is an Injector? An injector is an instrument or device in which a jet of steam imparts its velocity to water, and forces it into the boiler against the weight of

the water and that of the steam pressure contained in the boiler.

The principal parts are very similar in all classes of injectors. They consist of a *steam nozzle,* through which the operating steam from the boiler enters the injector; a *combining and condensing nozzle,* in which the steam and feed-water meet, and in which the steam condenses and transmits its force to the water, and a *delivery nozzle,* in which the maximum velocity of the combined mixture of steam and water is attained and subsequently reduced by means of the expanding curves or tapers and the increasing cross section, to the velocity and pressure in the boiler pipe.

The three parts mentioned are to be found in every injector.

In starting the injector, more water as a rule enters the apparatus than the injector is capable of delivering against the back pressure of the boiler. If there were no communication with the atmosphere the injector would refuse to work and the steam would blow back into the tank from which the water is taken, as this channel offers the least resistance.

The Principle and Action of an Injector. The action and principle of an injector is based on the fact that the velocity of steam which escapes from the boiler at a given pressure is much greater than that of water under the same conditions.

It is very difficult, and, in fact, almost impossible to properly explain the action of the injector without entering into mathematical demonstration and deductions, which would lead too far for instruction purposes. It will be necessary therefore to confine our instructions to the results of such mathematical deductions. The most simple method of considering the action of the injector is to view it from purely a mechanical standpoint as an apparatus in which the force of a jet of steam is imparted to a more slowly

moving body of water, resulting in a final velocity sufficient to overcome the pressure in the boiler.

We will consider, for example, a boiler containing steam at 120 pounds pressure. According to the laws governing the flow of steam through properly built channels, the steam discharging through the minimum diameter of the steam nozzle into the atmosphere, or steam of a low pressure, will reach a velocity of about 1,400 feet per second, but when it discharges into a combining tube, in which there is an average of a 20-inch vacuum (which is not unusual) the velocity will be about 3,500 feet per second.

In supplying water to the injector at the rate of about 13 pounds to 1 pound of steam, which is considered a fair performance at the pressure stated, the water will receive the impulse of the moving steam, condensing the latter, and the two fluids will move through the delivery tube with a final velocity which is very much less than the original velocity of the steam jet. This final velocity, under the conditions named, is about 170 feet per second, and in order that the injector should work properly this velocity must be greater than that with which the water in the boiler would issue from the delivery nozzle under a pressure of 120 pounds per square inch. This velocity is equal to that due to the main body of steam, corresponding to 120 pounds pressure or about 133 feet per second.

It is apparent therefore that there is a considerable margin of available energy in favor of the moving mixture of steam and water, as against the stationary resistance under the same pressure of steam and water in the boiler. An injector must have the proportions of steam, water and delivery areas so designed that the velocity of the moving mixture of steam and water will be greater than the velocity at which a jet of water would flow from the boiler under a corresponding pressure. If the amount of water supplied is too great, the steam will not have power to give the water

the required surplus of velocity. Also if there is an insufficient supply, the volume of steam will not be sufficiently reduced by condensation to pass through the nozzles, and in neither case will the injector properly perform its functions."*

*G. A. Bischoff.

In connection with the principle and action of the injector there are several conditions to be considered. One of the conditions is that the injector refuses to lift promptly or lift all the water. This may be caused by leaky joints in the suction-pipe, by improperly packed water valve-stem, by dirty or clogged strainers, clogging of the lifting steam passages in the injector, or a hot suction-pipe, which is one of the principal causes of injectors failing to start. Partial attention should be given to the strainer. It should be taken out, examined, and thoroughly cleaned before each trip. The old adage is especially applicable to the care of the strainer, as "An ounce of prevention is preferable to a pound of cure."

The care and attention given the strainer in many instances prevents a great deal of annoyance, expense and engine failures. When the injector lifts the water but refuses to force it into the boiler, or forces only part of the supply into the boiler and part through the overflow, it is usually caused by an insufficient water supply, as a result of improper size of the suction-pipe, hose or tank valve opening, or water-valve not being given the proper opening. This defect in the opening of the suction-pipe, hose or tank valve especially affects injectors on high pressure boilers. In addition to the defects previously described, in many instances the opening at the boiler check is insufficient for free admission of the water to the boiler. The pipes of an injector should never be smaller than the sizes called for by the injector connections, and more especially the feed-pipe and opening of the tank valve.

NATHAN "88" MONITOR INJECTOR—LEVER MOVEMENT.

List of Parts.

1. Body (back part)
2. Body (front part)
3. Body Screw.
4. Steam Bonnet and Nut
5. Lever Handle
6. Guide-Bar
7. Guide Sleeve
8. Center Bolt
9. Fulcrum Bolt
10. Fulcrum Bar
11. Clamp Bolt and Bushing
12. Friction Clamp
13. Steam Valve Spindle
14. Lifting Valve
15. Steam Valve
16. Water-Valve
17. Water-Valve Bonnet
18. Water-Valve Handle
19. Water-Valve Top Nut
20. Lifting Nozzle
21. Steam Nozzle
22. Intermediate Nozzle
23. Condensing Nozzle
24. Delivery Nozzle
25. Overflow Nozzle
26. Heater Cock Check
27. Heater Cock Bonnet and Nut
28. Heater Cock Spindle
29. Heater Cock Handle
30. Heater Cock Top Nut
31. Line Check Casing
32. Line Check-Valve
33. Stop Ring
34. Coupling Nut
35. Tailpiece

Interchangeable Parts of the Screw Motion Injector:

36. Steam Spindle
37. Yoke
38. Yoke Gland
39. Yoke Packing Nut
40. Yoke Lock-Nut
41. Steam Valve Handle
42. Steam Valve Rubber Handle
43. Water-Chamber

Operation. To operate the injector pull out lever 5 (Fig. 1) for a short distance; this unseats valve 14 and

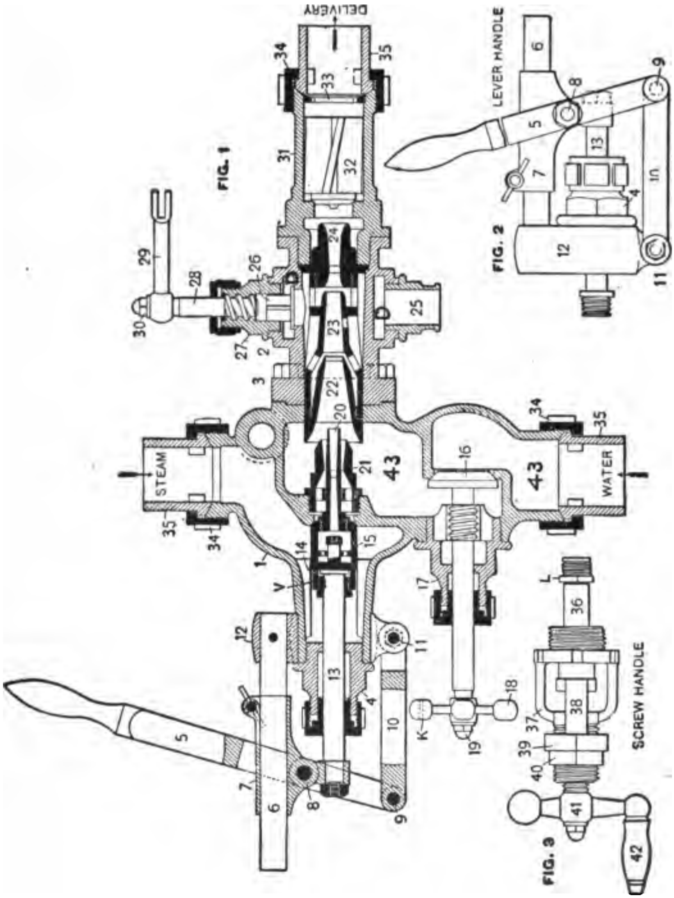


Fig. 1. Nathan "88" Monitor Injector.

allows a jet of steam to pass through lifting nozzle 20 and intermediate nozzle 22; thence by heater cock check-valve 26, through the spills D to overflow nozzle 25, thus creating a vacuum in the body of the injector, and over the water in feed pipe, causing the water to be forced to the body of the injector by the aid of atmospheric pressure; then through nozzle 22, heater valve 26 to passage D and to the ground. When the water runs from overflow 25 steadily, pull back lever 5; this unseats steam valve 15 and allows the steam to pass through steam nozzle 21 and combine with the water in intermediate nozzle 22, which is then forced through condensing nozzle 23 and delivery nozzle 24 past line check-valve 32; then through the delivery pipe, unseating the boiler check and passing into the boiler.

The steam supply should not be increased after the water has ceased to run at the overflow. The regulation of the supply should be governed by water-valve handle 18.

To convert into a heater, close heater cock check handle 29 and pull out lever 5 to its extreme travel, closing water-valve 16 to regulate the amount of steam needed in the feed pipe.

NATHAN MONITOR INJECTOR—SCREW MOTION.

List of Parts.

101. Body (back part)
102. Body (front part)
103. Body Screw
104. Yoke
105. Yoke Gland.
106. Yoke Packing Nut
107. Yoke Lock-Nut
108. Steam Valve Disk and Nut
109. Steam Valve Spindle
110. Steam Valve Handle
111. Steam Valve Rubber Handle
112. Steam Valve Top Nut
113. Jet Valve Disk and Nut
114. Jet Valve Spindle

115. Jet Valve Bonnet and Nut
116. Jet Valve Gland
117. Jet Valve Lever Handle
118. Jet Valve Top Nut
118-a. Jet Tube
118-b. Lifting Nozzle
119. Water-Valve
120. Water-Valve Bonnet
123. Water-Valve Handle
125. Steam Nozzle
126. Intermediate Nozzle
127. Condensing Nozzle
128. Delivery Nozzle
130. Line Check Casing
131. Line Check-Valve
132. Stop Ring
133. Overflow Nozzle
134. Heater Cock Check
135. Heater Cock Bonnet and Nut
136. Heater Cock Spindle
137. Heater Cock T Handle
138. Coupling Nut (steam end)
138-a. Tailpiece (steam end)
139. Coupling Nut (water end)
139-a. Tailpiece (water end)
140. Coupling Nut (delivery end)
140-a. Tailpiece (delivery end)
141. Water-Chamber
142. Vacuum Chamber

Operation. The Monitor Injector, Screw Motion, (Fig. 2), is operated in the following manner:

Water-valve 119 is opened by means of lever 123, which admits water into chamber 141; valve 113 is then opened by means of lever 117, which admits steam into tube 118-a, escaping into the overflow, thus creating a partial vacuum in chamber 141, by means of which communication is formed with chamer 142. With valve 134 open, water is forced from tank into chamber 141, through nozzle 126, and escapes at the overflow. When water appears at the overflow, steam valve 108 is opened by means of steam valve handle 110, admitting steam to nozzle 125, combining with the water in the intermediate nozzle 126 and is condensed and forced through the condensing nozzle 127; thence through delivery nozzle 128, by line check-valve 131, through delivery pipe 140-a, unseating boiler check and

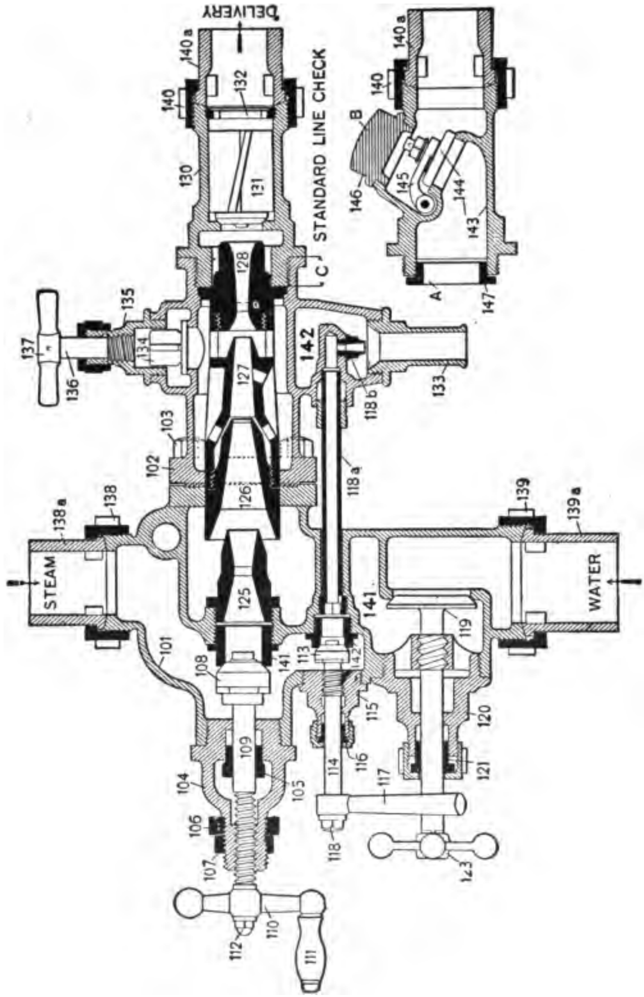


Fig 2. Nathan Monitor "XX" Injector.

supplying the boiler. After the injector is working, valve 113 is again closed to prevent steam from escaping at the overflow.

NATHAN SIMPLEX INJECTOR.

List of Parts.

1. Body
2. Steam Bonnet
3. Steam Packing Nut
4. Lever
5. Lever Handle
6. Guide for Steam Spindle
7. Guide Pin
8. Lever Pin
9. Fulcrum Bar
10. Fulcrum Pin
11. Steam Spindle
12. Lock-Nut
13. Water-Valve
14. Water-Valve Bonnet
15. Water-Valve Nut
16. Water-Valve Handle
17. Water-Valve Top Nut
18. Inlet Valve Cap
19. Inlet Valve
20. Inlet Valve-Seat
21. Steam Nozzle
22. Lifting Steam Nozzle
23. Intermediate Nozzle
24. Combining Nozzle

24-a. Combining Nozzle

25. Delivery Nozzle
26. Heater Cock Check
27. Guide for Heater Cock Check
28. Nut for Cam Casing
29. Cam Casing
30. Cam
31. Cam Lever
32. Nozzle Holder
33. Line Check-Valve
34. Overflow Nozzle
35. Emergency Valve
36. Packing Nut for Emergency Valve
37. Coupling Nut

37-a. Ball Joint

37-b. Brazing Ring

39. Overflow Coupling Nut
40. Overflow Tailpiece
46. Guide for Heater Cock
47. Heater Cock Spindle
48. Heater Cock Handle

Description. The Simplex injector is what is termed an automatic instrument and will restart after being inter-

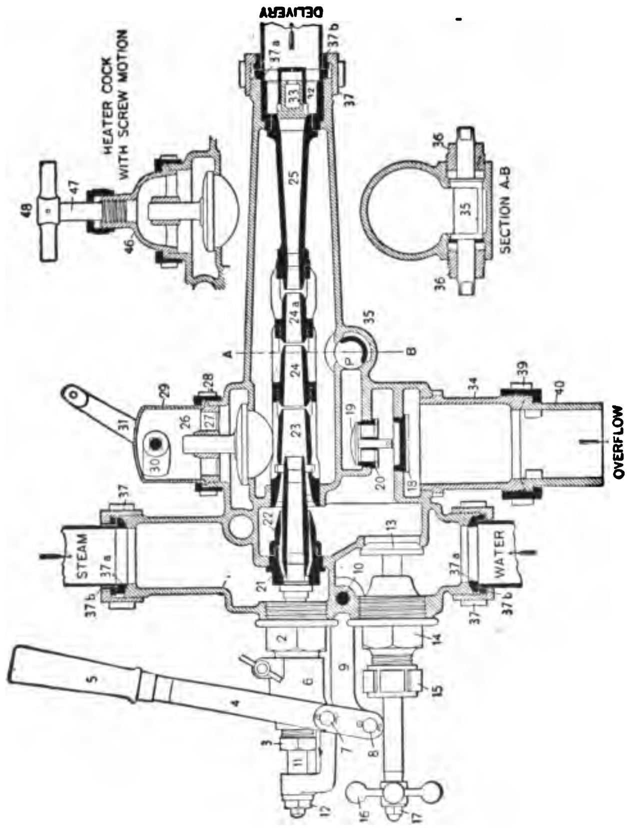


Fig. 3. Nathan Simplex Injector.

rupted from any cause, such as water surging in the tank when the supply is low, or a bad kink in the hose when the engine goes around a sharp curve, shutting off a part of the water supply. It is also self-regulating, controlling the water without waste at the overflow, with a varying pressure of steam of from 50 to 200 pounds without any regulating on the part of the engineman. Whenever the steam pressure is below 50 pounds the water must be regulated by the water-valve. It will start readily, even with a hot feed pipe.

This injector is provided with an extra waterway which is controlled by an inlet valve 19 (Fig. 3), which valve serves to increase the injector's capacity at steam pressure above 150 pounds. Should valve 19 leak or fail to seat, the emergency valve 35 may be turned one-half turn, and this extra waterway shut off; the injector will then start and work as an ordinary injector. The range of this injector is nearly 60 per cent, and is obtained by regulating the water-valve 13. The steam valve should be fully open at all times. The thumbscrew on the lever guide is to keep lever 4 in a slightly open position whenever the injector is used as a heater, so that the entire pressure may not be exerted on the hose.

Manipulation. To use the injector as a heater, close the heater cock check and draw out the starting valve a sufficient distance to permit the necessary amount of steam to flow back into the tank and to the frost cock at the delivery pipe. When starting the injector on high lifts and when lifting hot feed-water, pull out the starting lever slowly. To start the injector under ordinary conditions, pull the lever a short distance until the water is freely flowing from the overflow, and then pull level 4 the full length of its stroke. To stop the injector, push in lever 4 the full length of its stroke.

DEFECTS.

Should the injector get hot when not in use it is evident that the steam valve leaks and should be ground in. If there is any difficulty in starting the injector, it may be the inlet valve that is unseated. If this is found to be the trouble turn emergency valve 35 a half turn, closing passage P and continue the use of the injector until valve 19 can be repaired.

NEW NATHAN IMPROVED NON-LIFTING INJECTOR—TYPE "M."

List of Parts.

1. Body
2. Yoke
3. Yoke Gland
4. Yoke Packing Nut
5. Yoke Lock-Nut
6. Steam Valve Spindle
7. Steam Valve Lock-Nut
8. Steam Valve and Priming Nozzle
9. Universal Joint
10. Water-Valve
11. Water-Valve Bonnet and Nut
16. Steam Nozzle
17. Intermediate Nozzle
18. Condensing Nozzle
19. Delivery Nozzle
20. Line Check Nut
21. Line Check Nipple
22. Line Check
23. Line Check-Valve
24. Line Check Cap
25. Drain Plug
26. Heater Cock Check
27. Heater Cock Bonnet and Nut
28. Heater Cock Spindle
29. Heater Cock Handle
30. Overflow Body
31. Air-Chamber
32. Air-Chamber Nipple
33. Coupling Nut
34. Tailpiece
35. Overflow Nut
36. Upper Overflow Nut

Description. Fig. 4 shows a cross sectional view of an improved form of non-lifting injector, which is known as

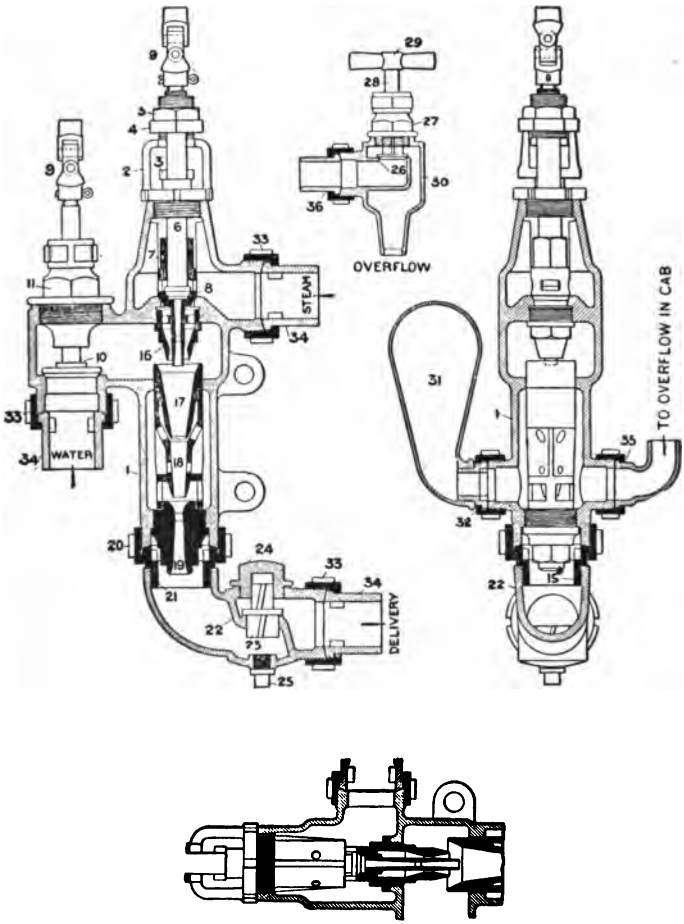


Fig. 4. Nathan Non-Lifting Injectors, Type "M."

the Type "M." It is provided with water regulating valve 10, and it also has priming nozzle and steam valve 8 within the body of the injector. The injector overflow valve is not contained within the body of the injector in this type of non-lifting injector, but is usually placed in a convenient position inside the engine cab, and about six inches above the highest water level in the tank, and is connected with the elbow at the back of the injector by means of a pipe, which must be of the size called for by the overflow connection.

The overflow connections on the body and the air-chamber are interchangeable, so that the injector can be used on either the right or left side. The object of placing the overflow pipe in the cab is to have it under the direct observation of the engineman, who is then able to see whether the injector is working properly. By placing the overflow valve above the highest water level in the tank, the loss of water is prevented when the injector is not in service and the overflow need not be closed unless the injector is used as a heater.

The claims of this injector for superiority over others may be briefly summarized as follows:

1. It will start readily at all times and under all circumstances. Hot delivery pipe, leaks and defective boiler checks, which cannot always be avoided, will not affect its prompt starting, as they do that of lifting injectors, or non-lifting injectors which have not the new improvements.

2. It will not lose more water in starting than any lifting injector, as the overflow is in sight of the engineman.

3. When once regulated to the requirement of the service it is a perfect one-motion machine. It is started by simply turning on the steam.

4. The nozzles of this injector will not corrode, as the body is comparatively cool, being always charged with water.

5. Steam from a leaky steam valve will not show at the overflow, and obscure the view through the cab window.

The injector can be regulated to a 50% range so that it is suitable for heavy as well as light service.

Operation. When first starting this injector, the tank valve should be wide open. Water-valve 10 should then be opened by means of the handle in the cab, after which the primer 8 should be opened a quarter turn. This will raise the steam valve off its seat, and allow steam to pass into the priming nozzle through openings shown in Fig. 4, and down through the nozzles of the primer valve. The steam as it issues from the priming nozzle is condensed by the incoming water and imparts to the latter sufficient velocity to carry the water and condensed steam through nozzles 17 and 18, and out through the overflow pipe, and out of the overflow in the cab. As soon as the water appears at the overflow, the primer valve should be given a greater opening, which will have the effect of unseating the steam valve 8, allowing steam to pass out through the larger opening made, and down through the steam nozzle 16. This will give the water a still greater velocity, enabling it to raise check-valve 23, and pass into the boiler. The quantity of the water supply should be regulated by water-valve 10.

To stop the injector, the steam valve should be closed and the water-valve left open ready for the next starting. This will keep the injector body full of water and prevent scales from accumulating.

To use the injector as a heater, heater cock check 26 should be closed, after which the steam valve should be opened very slightly. In very cold weather the drain plug 25 may be replaced by a drain cock, for the purpose of keeping the injector and overflow pipe free from water when not in service, in which event the tank valve must be kept closed.

OHIO INJECTOR.

List of Parts. Fig. 5 shows a sectional view of the Ohio injector, which consists of the following parts:

1. Body (back part)
2. Body (front part)
3. Delivery End Connection
4. Steam Valve Hub complete
5. Steam Valve and Primer complete
6. Steam Nozzle
7. Lifting Tube
8. Combining Tube
9. Delivery Tube
10. Line Check-Valve
11. Stop Ring
12. Overflow Valve complete
13. Water-Valve complete
14. Lever
15. Overflow Nozzle
16. Primer Nozzle

Description. The Ohio injector is noted for its simplicity, having but few parts and those conveniently arranged for repairing. By referring to Fig. 5 it will be noted that the combining and delivery tubes are screwed directly to the delivery end connection on the right, and can be removed with an ordinary wrench without disturbing other tubes. The lifting tube is held in place between the two flanges, which are bolted together.

This injector will also work feed-water at a higher temperature than the ordinary lifting injector, except those which are designed for the purpose of working feed-water at high temperature, and is interchangeable with all other lifting injectors in common use, the sizes and location of the connections being similar.

Operation. To operate the Ohio injector open water-valve 13 and pull out lever 14 a short distance. This unseats steam valve 5 and allows steam to pass through primer nozzle 16 through lifting tube 7, passing overflow valve 12, through passages DD, thence through overflow

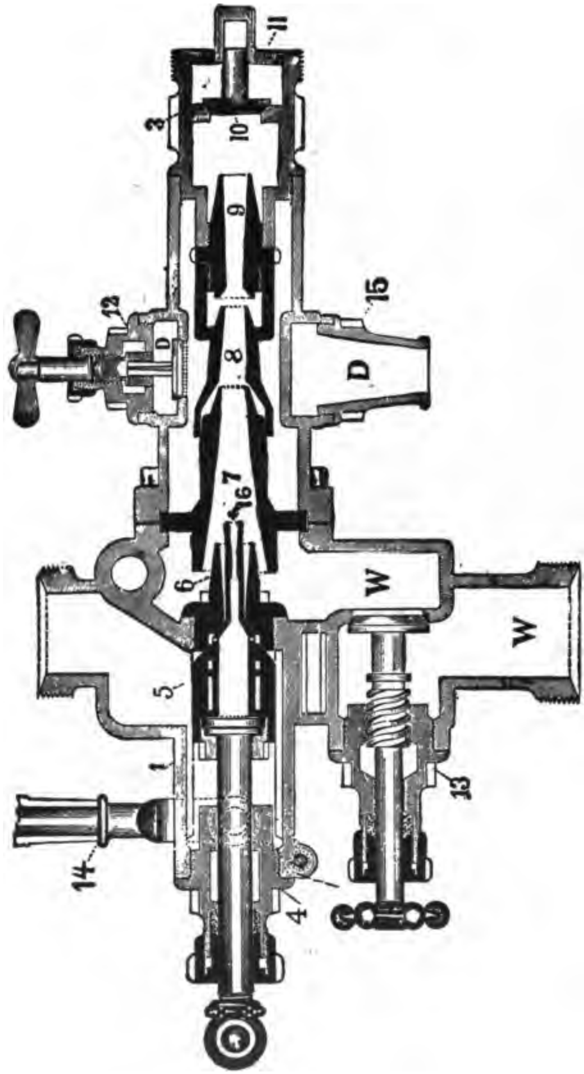


Fig. 5. Ohio Injector.

nozzle 15. This creates a partial vacuum in chambers WW and over the water in the feed pipe, which allows the water to enter chambers WW, taking the course of the steam from primer jet 16. When water is flowing freely from overflow 15, lever 14 should be pulled back its full stroke, or to its extreme travel. This opens steam valve 5 to its maximum, and steam is then free to flow through steam nozzle 6 into lifting tube 7, combining with the water in combining tube 8, and is forced through delivery tube 9, unseating line check-valve 10, which allows the water to pass into the delivery pipe, unseating the boiler check and allowing the water to enter the boiler. The supply of water required in the boiler is regulated by water-valve 13.

THE HANCOCK INSPIRATOR.

Operating Parts.

101. Lifter Steam Nozzle
102. Lifter Tube
103. Forcer Steam Nozzle
104. Forcer Combining Tube
106. Connecting Rod
111. Line Check-Valve

117-c. Final Overflow Valve
121. Intermediate Overflow Valve
126. Forcer Steam Valve
130. Lifter Steam Valve
131. Stud in the Lever
137. Lever

Description. The Hancock inspirator consists of an apparatus for lifting and one for forcing. With this distinguishing feature, common to no other injector, the Hancock inspirator works successfully under the most severe conditions, with high or low steam pressure or on lifts up to 25 feet, when taking feed-water under a head, with feed-water at a high temperature, as well as cold water. At all steam pressures and under all conditions, its operation is the same and it requires no adjustment for variation of pressures. Plate 1, Fig. 1, shows an exterior view of the inspirator and Fig. 2 a sectional view.

The lifting mechanism consists of a steam nozzle and a combining tube. The throat of the combining tube being much larger than the smallest opening in the steam nozzle enables it to increase or diminish the amount of water as the pressure of steam increases or decreases. As the press-

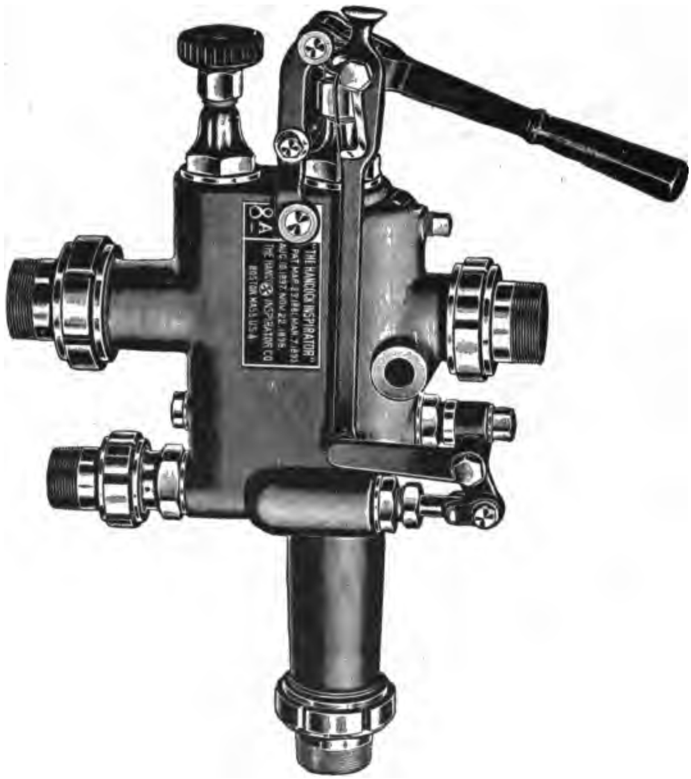


Plate 1, Fig 1. Hancock Inspirator.

ure of steam increases the pressure in the delivery chamber of the lifter is increased, enabling the water to enter the forcer combining tube against the increased pressure of steam from the forcing nozzle, thus enabling it to work

from low pressure to high pressure without any adjustment of either steam or water supply.

At times the inspirator will not work satisfactorily with the regulating valve wide open or at its maximum, but will

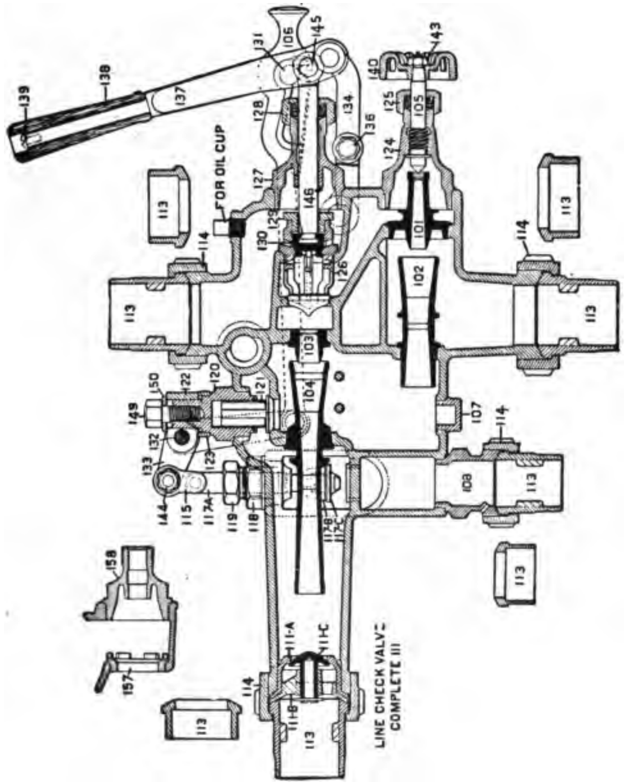


Fig. 2, Plate 1. Hancock Inspirator.

work when this valve is partially closed or when at its minimum. This indicates an insufficient steam supply. It may be due to contracted openings in the valve next to the boiler, combination box, or the dry pipe leading to the combination box being too small, which should be remedied. An insuffi-

cient supply of water caused by a small-sized or restricted opening in the tank valve, small opening in the goose neck leading to the tank, insufficient opening in the strainer, a kinked or partially collapsed hose, or leaks in the feed pipe, would cause the inspirator to break.

Operation. To start the inspirator, draw lever 137 back slightly to lift the water, then draw it back to the stop. When lever 137 is drawn back slightly, steam is admitted to lifter steam valve 130, through forcer steam valve 126, to lifter steam nozzle 101. The flow of the steam into lifter tube 102 creates a vacuum and causes the water to flow through lifter tube 102, condensing the steam, and out through intermediate overflow valve 121, and through the final overthrow valve 117-c in the delivery chamber. A further movement of lever 137 opens forcer steam valve 126, admitting steam to forcer steam nozzle 103, and to forcer combining tube 104, creating a pressure in the delivery chamber sufficient to close intermediate overflow valve 121, and open intermediate or line check-valve 111. The final overflow valve 117-c will be closed and the inspirator in full operation when the lever is drawn back to the stop. When the pin in the wheel of the regulating valve is at the top, the inspirator will deliver its maximum quantity of water; to reduce the feed, turn the regulating wheel to the right.

To use the inspirator as a heater, lift connecting rod 106 until disengaged from stud 131, then draw back the connecting rod to close overflow valve 117-c. Draw the lever back to the point used in lifting. This will usually give all the steam that is required for a heater. If the amount of steam flowing back into the tank is too large, regulate it by the regulating wheel to the amount required. With the lever in this position all steam blowing back will pass through the lifter nozzle. The closing of the main steam valve at the boiler is unnecessary.

GENERAL INFORMATION RELATING TO INJECTORS.

CLASSES OF INJECTORS.

Locomotive injectors are divided into two classes—lifting and non-lifting. A non-lifting injector must be located below the bottom line in the tank, so that water will flow freely to the injector by gravity. A lifting injector when in operation raises the water above the level of the water in the tank, and is the class of injector most commonly used on locomotives. The majority of non-lifting injectors are not provided with what is termed a priming jet, but are supplied simply with a force jet, which forces the water which flows by gravity into the injector into the boiler. The point of overflow on the old style of non-lifting injectors is usually at a level with the injector, which necessitates the overflow being closed when the injector is not in service. The later types of non-lifting injector are equipped with a combined overflow and heater cock, which is connected by a pipe with the injector body and extends into the cab within convenient reach of the engineer. This injector can be used as a heater in the same manner as the lifting injector. Also the overflow is in sight of the engineman at all times, where he will be able to determine whether or not the injector is working properly.

Both Injectors on the Right-Hand Side of the Engine. On some locomotives on the various lines both injectors are placed on the right-hand side of the engine. The purpose of this arrangement is to relieve the fireman of the operation of the injector usually located on the left-hand side, both injectors being placed within con-

venient reach of the engineman. Each injector is provided with an independent check-valve and delivery pipe (Fig. 9). Both injectors inject the water into the boiler through a pipe in the shape of a goose neck, located in the boiler where the check is usually placed. The valves are provided with removable seats, shown in Figs. 8 and 9. By closing stop valve A, check-valves BB and their seats may be removed for inspection or repairs while the boiler is under steam. This type of check-valve is provided with hubs on the body between the stop-valve and the check-valve, for the purpose of inserting an independent drain valve.

Injectors Working Feed-Water of High Temperature. Injectors will not work feed-water that is heated to a point beyond the requirements of the water for condensation of the steam which is admitted to the injector and transmits its force to the water in the combining and condensing nozzle. One of the principles upon which the injector operates is the high velocity of steam entering the steam and combining nozzle, where it meets the water and transmits its maximum velocity, combined with the mixture of water, into the delivery nozzle, whereby it is reduced by means of the expanding curves or tapers. Hence it is apparent that the lower the temperature of the feed-water the greater the condensation will be when the steam combines with the water, which will cause the injector to increase its capacity, or discharge of water, into the boiler. It will also be understood that the higher the steam pressure the lower the temperature of the feed-water should be for a given amount of water to be injected into the boiler. The lower steam pressure being of a lower temperature will work the feed-water at a higher temperature, to accomplish a given amount of work by the injector.

There are special designs of injectors which will work

feed-water at a higher temperature than the ordinary lifting or non-lifting injector. It is always desirable that feed-water with all classes of injectors be heated to a temperature as high as the injector will work without affecting its efficiency under the various conditions which are to be met in road service. However, the heating of the feed-water is a matter which must be watched closely by the engineman, for the reason that if it be neglected it may reach a higher temperature than will allow the injectors to furnish the necessary amount of water to supply the boiler. The heating of the feed-water must also be regulated according to the particular class of service; that is, engines in passenger or light freight service may use a higher temperature of feed-water than engines engaged in the handling of heavy traffic, the temperature to be regulated by the class and capacity of the injector in use.

Causes of Injectors Located on Left-Hand Side of Engine Failing to Work. Injectors located upon the left-hand side of the locomotive are frequently neglected by the engineman, and fail to work when needed, by reason of their being allowed to remain idle until such times as the failure of the right-hand injector demands their use. During the time the injector remains idle, its parts become corroded with lime and other impurities contained in the water. The boiler check also becomes corroded to an extent which causes it to remain closed, the injector not being able to raise the check off its seat to admit the water into the boiler. The neglect of the left-hand injector frequently causes engine failures, which could be avoided had it received the necessary care and attention each trip.

Failures of Injectors. If the injectors refuse to work, the engine throttle should be closed and immediate attention be given to the water supply. It should be

noted that the tank valves have the necessary opening and are not disconnected from the stem. If the siphon feed pipe or valve is in use the plug or vent should be looked at, to see that it is closed and that no air is admitted to the feed pipe. The water in the tank should be looked at, to see that there is a sufficient supply for the operation of injectors, making allowance for the surge of the water in the tank when the engine is in motion. The hose should receive attention, to see that it is not disconnected and is properly coupled and not kinked and that no air is admitted at that point. The strainers should be examined, to see that they are not clogged and that a sufficient amount of water may pass through them to allow the injector to operate. The heater valve should be given attention, to see that it is not closed and that the connection of the feed pipe to the injector is tight, so that no air is admitted at the union. The manhole cover of the tank should receive attention, to see that it is not air-tight, as one of the principles of the lifting injectors is that atmospheric pressure which enters the tank on top of the water assists in raising the water to the injector, where it combines with the steam and is forced into the boiler.

INJECTOR DEFECTS.

The principal defects of the injector, which prevent the starting of the instrument, are due to steam leaking by the main steam valve or water leaking by the boiler check, which prevents the injector from priming, as these leakages destroy the vacuum in the feed pipe above the water. Injectors which are equipped with independent priming valves at times become disconnected, which prevents them from priming. The main steam valve at the fountain should receive attention, to see that it has

the proper opening to supply the necessary amount of steam for the operation of the injector.

Other defects in the injector which will cause it to fail are as follows:

Too great a volume of steam admitted to the injector for the volume of water admitted to condense; leaks in the feed pipe; a loose steam, combining or delivery nozzle; the nozzles or tubes being out of line or corroded; the boiler check becoming stuck so that it cannot be raised, or the globe valve in the delivery pipe being closed.

When steam continues to blow at the overflow on the Monitor injector it can be determined as to whether the leak is in the primer or throttle valve by putting the injector to work. If, when the injector is working, the escape of steam at the overflow ceases, it indicates that the throttle valve is leaking, but if the blow continues it would indicate that it is the primer that is leaking. If both water and steam flow from the overflow when the injector is not in use, it indicates that the boiler check is leaking.

Causes of Injectors Forcing Only Part of the Water Into the Boiler. When an injector lifts the water but forces only a part of it into a boiler, the balance being forced through the overflow to the ground, it may be caused by an insufficient water supply, due to the feed pipe having too small an area in proportion to the size of the injector; a kinked hose which reduces the water supply; a tank valve that is partly closed or the water-valve in the injector not given its full opening; obstructions in the nozzles caused by pieces of coal, scales, waste, etc., passing through the strainers; an insufficient lift of the boiler check; the boiler check opening only partially or the line check only partially open, due to corrosion.

Incrustations or corrosion of the nozzles by limy deposits will cause the injector to spray and will result in the improper working of the instrument. The injurious effects of bad water and the corrosion of the tubes may be overcome by frequently cleaning and placing the instrument in an acid bath, which removes incrustations and all other limy deposits accumulated on its various parts.

Converting an Injector Into a Heater. All injectors may be converted into heaters by closing the heater valve and opening the injector throttle enough to furnish a supply of steam back through the feed pipe and hose to the tank, in addition to furnishing a supply of steam through the delivery pipe to the frost cock, usually located in the delivery pipe, near or connected to the check-valve. Steam must escape from the frost cock at all times to prevent freezing of the delivery pipe. Particular attention must be given to the heater by the engineman at all times, as the frost cock frequently becomes clogged by scale, dirt, or other matter, and stops the circulation of steam in the pipe, which will then freeze within a short period of time. The engineman should also give particular attention to the heater working into the tank. The volume of steam being admitted to the tank may be regulated by the water-valve. The tank valve should also be nearly closed to prevent the inrush of water into the hose and feed pipe during the time the injector is used as a heater.

How to Thaw Out a Feed or Delivery Pipe Which May Have Become Frozen. To prevent damage by bursting, when thawing out, of the feed or delivery pipes which may have become frozen, the connection between the hose and feed pipe should be thawed first. The joint should then be broken to allow the water to pass out of the feed pipe as fast as the thawing takes

place. The pipe should then be thawed from the coupling of the hose to the connection with the injector, or as far as it may bave become frozen. The feed or delivery pipes should never be thawed without an opening for the water to escape, for the reason that the thawing of the pipe which is frozen on each side of the water will expand and burst the pipe, as the pressure of the expansion cannot be relieved. After the feed pipe has been opened, a slight jet of steam should be turned on, which will work itself back into the hose, the water from the ice and condensation of the steam escaping at the coupling. The steam will continue to thaw the frozen hose back to and past the tank valve to the water. Steam only should be used for the thawing of tank hose on the road.

Should the delivery pipe become frozen it should be thawed in the same manner; that is, disconnect or break the joint enough to cause a leakage at the connection to the injector, starting at that point and working forward. In the event the delivery pipe remained hot next to the check-valve and frost cock it would indicate that the check-valve was leaking slightly, and the frost cock should be opened or removed from the pipe, allowing the circulation of water from the boiler past the check-valve to pass out through the opening of the frost cock, which would also thaw out the pipe toward the injector.

To Operate an Injector With the Primer Disconnected. Injectors having independent priming valves may be operated when disconnected. In order to accomplish this, the main steam valve should be shut off at the fountain, taking out the primer valve and connecting it up if possible. If this cannot be accomplished the valve should be taken out, after which the remaining parts may be put back in place. The injector should then be primed by slightly opening the main valve at the fountain until

priming takes place, after which the main valve may be opened sufficiently to supply the necessary steam for the operation of the injector. After this movement is completed the injector throttle should be opened and the injector will go to work. To shut off the injector under those conditions, the valve at the fountain should be closed first and the injector throttle closed next. If the injector throttle on the injector were closed first, the instrument would still remain primed.

Foreign Matter in the Steam, Combining or Delivery Tubes. In the event of an accumulation of foreign matter in the steam, combining or delivery tubes, which interferes with the proper working of the injector, it can be removed by shutting off the steam at the fountain, and removing the main steam valve at the body of the injector, which will allow the obstructions to be removed by the use of a wire.

Care of the Engine When Injectors Fail on the Road. When injectors fail on the road, the first duties of the engineman are to close the throttle, drop the dampers, open the fire-box door to prevent the engine from blowing off, with a view of saving all the water there is in the boiler until the necessary repairs can be made to the injectors, without knocking the fire out of the engine. In the event of there being a heavy fire in the engine, and the opening of the door will not prevent blowing off, the fire should be extinguished by water or smothered by the application of a fine slack coal, in order that the water contained in the boiler will not be wasted, which allows more time for the repairs to the water supply without making a complete engine failure and giving up the train.

Disconnceted Tank Valve. A tank valve which may become disconnected closed can usually be opened or displaced by closing the heater valve and giving the

steam throttle in the injector a full opening, which will allow the steam to force its way back through the feed pipe and hose to the under side of the valve, forcing the valve from its seat.

BOILER CHECKS.

Purpose of the Boiler Check. The purpose of the boiler check is to prevent a return flow of water from the boiler when the injector is not in use. This valve is automatically closed when the injector is shut off, by the pressure from the boiler acting upon its upper surface. Careful attention should be given to the boiler check, as no type of injector will work in a satisfactory manner unless the boiler check is given the necessary opening. The boiler check should make a good tight joint on its

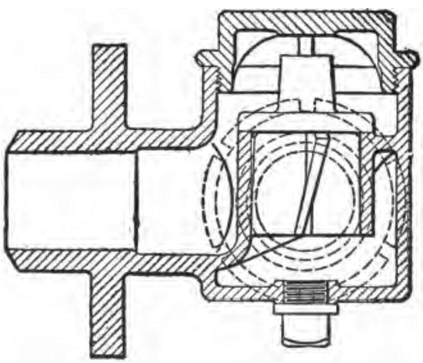


Fig. 7. Angle Boiler Check, Flanged.

seat at all times to prevent the water from flowing back into the injector, which in many instances causes it to fail. The boiler check is extremely simple in its construction and with a little care and attention can be kept

in perfect working condition. The type of checks in common use is usually provided with three or more lugs or wings, which are cast to the valve below its seat (Fig. 7). The purpose of these lugs or wings is to assist in reseating the valve centrally by acting as guides. These lugs or wings should not be fitted in the casing too loosely, as they are liable to become corroded and cause

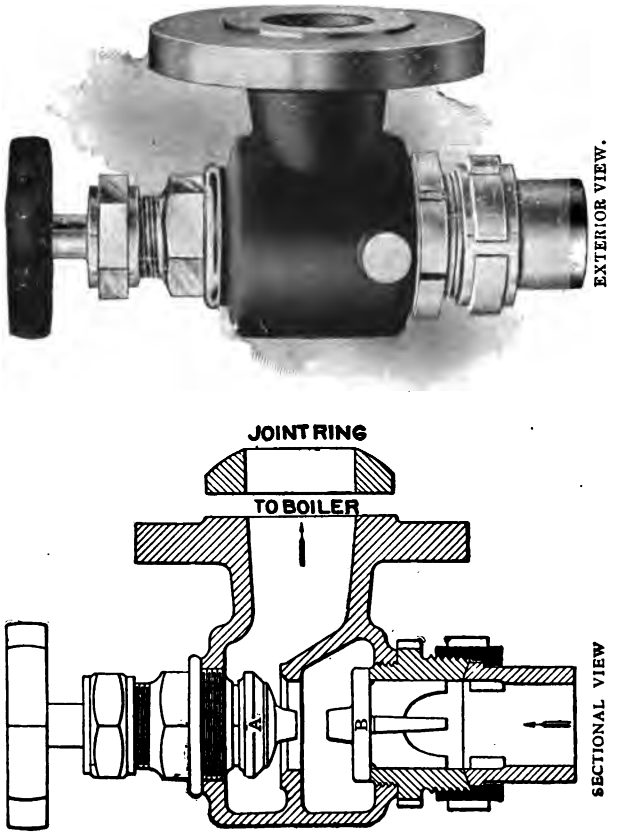


Fig. 8. Boiler Check with Stop Valve.

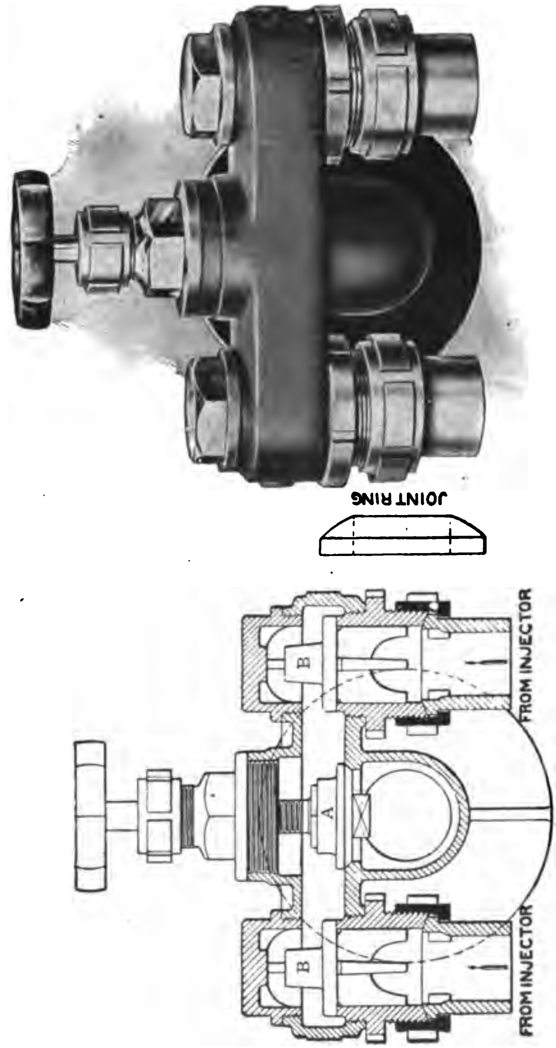
the valve to stick. In some of the improved types of check-valves these lugs are cast fan-shaped, or inclined from their seats, which creates a revolving check (Fig. 7). The lift of the check-valve should be in proportion to its diameter and the capacity of the injector, the lift varying with the different sizes of injectors and check-valves.

An additional or intermediate check-valve is used on some classes of engines, which is located in the delivery pipe between the injector and the boiler check. The purpose of the intermediate check-valve is to prevent a leakage past the check-valve from reaching the injector and causing it to heat.

How to Reseat a Boiler Check. The frost cock should be opened, which will allow the pressure from the boiler which passes the check-valve into the delivery pipe to escape, instead of passing back through the injector. The cage should be tapped lightly on the under side, which will assist in reseating the valve.

Care should be taken when tapping the check-valve that the blow will not be sufficient to dent or spring the cage in which the check-valve operates. The opening of the frost cock will relieve the pressure from forcing its way back into the injector to the extent that the injector will prime, after which the injector may be put to work and the water entering the boiler will usually remove the cause for the check remaining off its seat, after which the frost cock will be closed. The method of reseating the check-valve as described is applicable to type of boiler check shown in Fig. 7.

In the event that the check-valve cannot be reseated or the injector started by the methods previously described, it will be necessary to close the heater and water-valve to prevent the heated water from blowing back into the tank, causing the water to become over-



EXTERIOR VIEW.

SECTIONAL VIEW.

Fig. 9. Double Boiler Check Valve with Single Stop Valve.

heated. If the water-valve will not close tightly, it will be necessary to disconnect the hose from the feed pipe and open the heater cock, allowing the hot water to blow into the atmosphere instead of into the tank. If the opposite injector will not supply the boiler under these conditions it will be necessary to put the train on the first siding and fill the boiler, reducing the steam pressure, after which the delivery pipe can be disconnected at the check and the valve then reseated with the use of a suitable rod which can be inserted into the check-valve case and under the valve.

On some classes of engines the frost cock is tapped into the lower part of the check casing (Fig. 7), in which case the frost cock can then be taken out and a rod inserted under the check, raising the check farther off its seat and allowing the foreign matter to be blown from its seat. Under similar circumstances where there is a boiler check with stop valve, as shown in Figs. 8 and 9, this valve would be closed, which will prevent the hot water from flowing into the injector. The primer should then be opened, which will allow the injector to prime, and after the water has been allowed to flow through the injector freely until the instrument is cool the globe valve may be opened and the injector will go to work.

THE SIPHON TANK CONNECTION.

Some engines are equipped with what is known as the Siphon tank connection, which is used in place of the old standard tank valve. This type of water connection has a decided advantage over the old form of tank valve, as it is more easily and economically applied. It also eliminates the necessity of the strainer in the hose connections, which frequently becomes clogged, and is

one of the most frequent causes of injector failures. With the device shown in Fig. 10 there can be no flooding of the tank or gangway due to leakage of water at the tank valve-stem, which is always an element of danger in cold or freezing weather. In addition to this, the annoyance of disconnected tank valves, which necessitates the draining of the tank in order to permit their reconnection, is eliminated. It is also more easily kept from freezing.

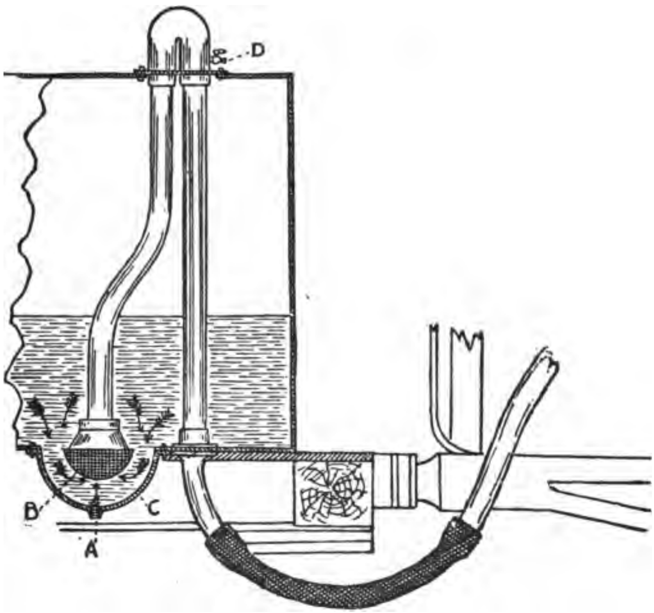


Fig. 10. Siphon Tank Connection.

One of its principal advantages over the old style tank valve is that it permits the use of a larger strainer with small openings, which allows a sufficient supply of water to enter the feed pipe and prevents foreign matter from enter-

ing the feed pipe and being drawn into the injector, stopping up the nozzles and tubes.

To Clean the Strainer on a Siphon Tank Connection. When the strainer on a siphon tank connection becomes clogged, it can temporarily be cleaned without stopping the engine, by closing the heater cock and opening the throttle fully, blowing the steam back into the tank, which removes all matter which has been drawn to the strainer on its exterior side. To clean the strainer and trap thoroughly the tank should be empty, plug A in the trap removed, allowing the steam to blow back sufficiently to drive the sediment or foreign matter out of strainer B and trap C, after which plug A should be replaced.

To stop the water from running constantly if the tank hose has become disconnected or is to be taken down for the purpose of making repairs the small pet cock D or plug, which is sometimes used, should be opened for the purpose of admitting air, which destroys the action of the siphon. The pet cock should be closed at all times when the siphon is in use.

STEAM-HEAT REDUCING VALVES.

There are several different types or styles of pressure reducing valves in use on the locomotive for the purpose of maintaining uniform pressure in steam-heat lines.

THE MASON VALVE.

Operating Parts.

A. Inlet for Steam
B. Outlet
C. Auxiliary Valve
D. Metal Diaphragm
E. Regulating Spring
F. Piston
G. Main Valve
H. Auxiliary Valve Spring
I. Main Valve Spring
NN. Steam Passage from Auxiliary Valve to Piston
XX. Steam Passage Leading to Diaphragm
OO. Chamber Under Diaphragm

Construction and Operation. The Mason reducing valve (Fig. 11) is one of the types of valves used on locomotives for steam heating purposes and in supplying steam to stationary engines used to operate dynamos in train lighting. The principle upon which this type of valve operates is as follows: Auxiliary valve C is controlled by low pressure in the heating system through the medium of metal diaphragm D. This diaphragm is controlled by spring E, which may be set for any pressure desired in the steam-heat line. Spring E forces auxiliary valve C off its seat when steam is admitted from the boiler at the side of the valve marked A. The steam is then free to pass auxiliary valve C through ports NN to the under side of piston F. By raising piston F the main valve G is also opened against the boiler pressure. By reason of piston F having a greater area than valve G, steam can then pass by valve G to the steam-heat line. When the pressure in the steam-

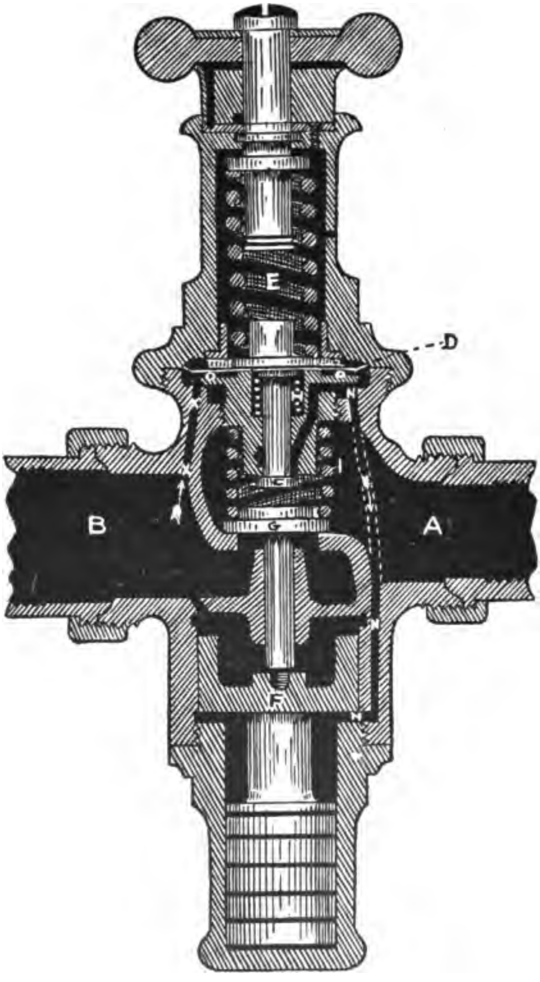


Fig. 11. Mason Steam-Heat Reducing Valve.

heat line has reached the pressure at which the regulating spring is set, diaphragm D is forced upward by the steam line pressure which passes through port XX to chamber OO under diaphragm D. This allows auxiliary valve C to close by the aid of the boiler pressure and spring H, thereby shutting off the steam from passage NN to the under side of piston F. The steam that is entrapped between piston F and auxiliary valve C is then free to pass by the loose fitting piston to the steam-heat line. The main valve G is now forced down to its seat by the boiler pressure and spring I, shutting off the steam from the steam-heat line and forcing piston F down to the bottom of its cylinder.

When the pressure in the steam-heat line and that in chamber OO under the diaphragm is slightly reduced below that of adjusting spring E, the valve will again open, permitting the steam to flow into the steam-heat line until the required pressure is attained.

THE TAAFEL STEAM-HEAT REDUCING VALVE.

Operating Parts. The Taafel steam-heat reducing valve (Fig. 12) consists of the following operating parts:

A. Inlet
B. Inlet Port to Regulating Valve Chamber
C. Regulating Valve
D. Adjusting Spring
E. Diaphragm
F. Port from Regulating Chamber to Piston Chamber
G. Piston
H. Main Valve
I. Outlet
J. Port to Diaphragm Chamber
K. Regulating Valve Spring
L. Main Valve Spring
M. Regulating Cap

Operation. Steam from the inlet side A enters from the right-hand side, shown in Fig. 12. A portion of the

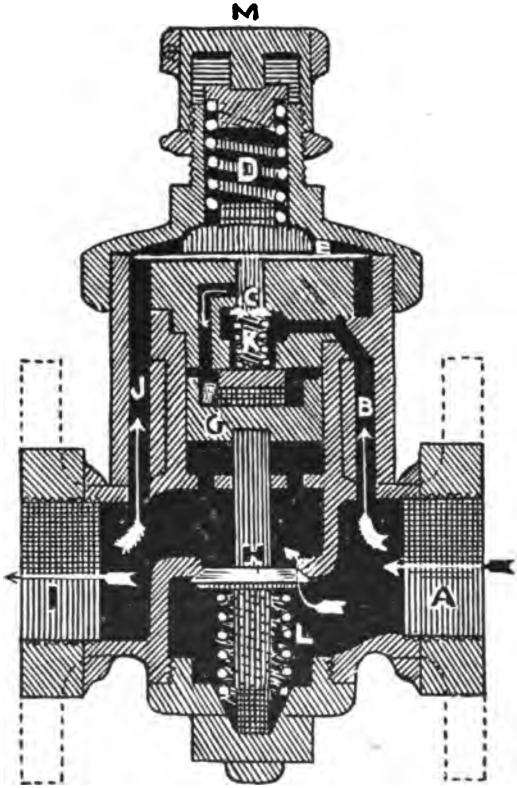


Fig. 12. Taafel Steam-Heat Reducing Valve.

steam passes up through port B to the regulating valve C, its normal position being off its seat, due to the downward pressure of the regulating spring D on the diaphragm E, which, in turn, bears upon regulating valve C. This valve being open, allows the steam to pass to chamber above piston G, which it forces downward, opening main valve H and allowing the steam from the boiler to pass to the train heating system at the outlet I. Port J connects the under side of diaphragm E with the heating system. When

the pressure under the diaphragm reaches the pressure that the adjusting spring D is set to withstand, the slightly additional pressure will cause diaphragm E to move upward far enough to release regulating valve C, allowing the valve to be seated by the tension of spring K. No further supply of steam from the inlet side can reach the chamber above piston G and all pressure that is entrapped above piston G can pass around the piston, the steam equalizing with the steam pressure underneath. Piston G being equally balanced, permits main valve spring L to close main valve H, shutting off further supply of steam to the heating system. As soon as the pressure in the steam-heat line and underneath diaphragm E becomes slightly reduced, adjusting spring D again forces the diaphragm downward, unseating regulating valve C, which again allows a supply of steam to the system. To adjust this valve, screw down on regulating cap M. This puts a tension on adjusting spring D. If too much pressure is admitted to the steam-heat system, slack off on regulating cap M, which reduces the tension on the adjusting spring D.

THE GOLD PRESSURE REGULATOR.

The Operating Parts.

A. Inlet
B. Outlet
C. Bolt and Nut for Dome and Body
DD. Balancing Spindle
F. Bottom Spring
G. Body of Regulator
H. Bottom Plug
I. Handle
J. Top Nut
K. Hollow Screw
L. Top Spring
M. Dome of Regulator
N. Lock-Nut
O. Top Flange
P. Bottom Flange
Q. Top Spindle
R. Set-Screw
T. Union Nut (Inlet)
U. Union Nut (Outlet)
VV. Main Valve
SS. Recesses

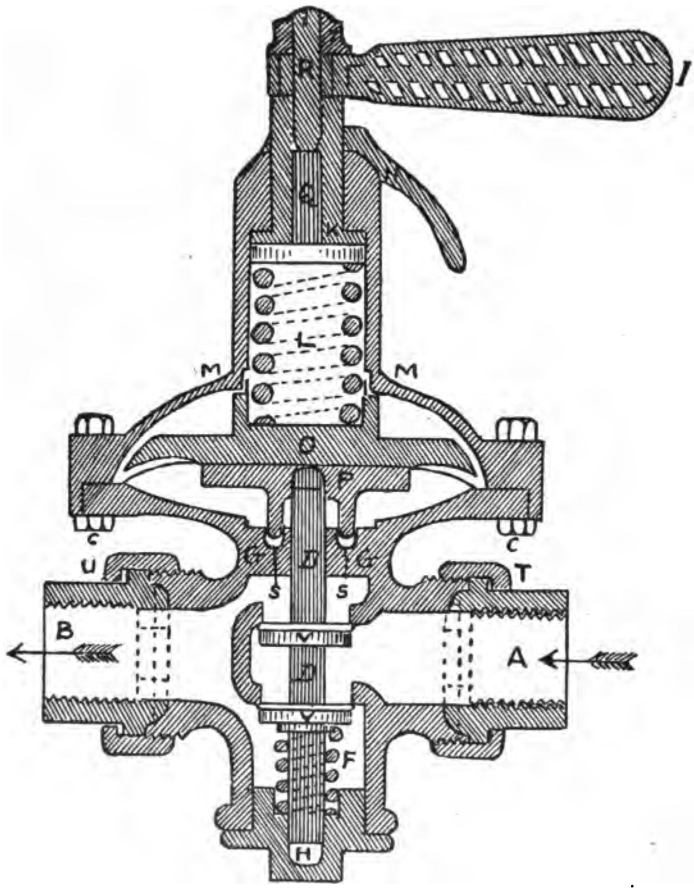


Fig. 13. Gould Pressure Regulator.

Construction and Operation. Fig. 13 shows a sectional view of the Gold pressure regulator and its parts. This valve is of the diaphragm type, and is nearly a balanced valve. The diaphragm is constructed of thin bronze, slightly corrugated on the outer edge, with an enlarged flange O, which aids the diaphragm in retaining its original shape.

The dome M of the regulator is solid, which would prevent the steam from escaping into the cab should the diaphragm break or become defective. The recess shown at SS provides a water-seal, which prevents a chattering or vibration of the valve.

The regulator is set by handle I, which is perforated for the purpose of keeping it cool. The handle marked N is an extension of a lock-nut, which holds the regulating screw firmly in any position at which it may be set. The set-screw R is provided for the purpose of a check on the maximum or minimum amount of pressure required. Spring L is controlled by set-screw R. Spring F assists in guiding the spindle DD and also tends to assist in the balancing of the valve, and aids in the operation of the valve and spindle should they become gummed or corroded in any manner. Main valve VV is opened and closed by the movement of the diaphragm. The regulating spring L forces the diaphragm down, the main valve remaining open until the steam from the outlet side of the valve closes the main valve.

DEFECTS OF REDUCING VALVES.

All reducing valves are subject to defects which cause them to become inoperative. When the main steam valve is cut or the auxiliary valve is leaking badly, the small spring which holds the auxiliary valve to its seat is usually found to be broken. Either of these valves held open, or the piston F off its seat in the Mason reducing valve, or piston G stuck down in the bushing with the Taafel valve, will also tend to hold the main valve to its seat. If the bottom spring is broken or missing it will also allow the steam to pass directly to steam-heat line, or if the tension of the adjusting spring is too great with any type of valve the pressure in the heating line will become too great.

Steam Failing to Pass Through Steam-Heat Valves.

Steam failing to pass through steam-heat valves indicates that there is no tension on the adjusting springs, or that they may be broken, and possibly parts of the valve missing in the spring casing, or no steam is admitted from the boiler to the valve.

Action to Be Taken by the Engineman When No Steam Will Pass Through Reducing Valve to the Steam-Heat Line. On the Mason reducing valve remove the casing below the piston and insert a washer or nut in the cap, and replace the casing. This will force the main valve off its seat.

On other types of valves take off the cap nut and remove the main steam valve, replacing the cap nut and govern the pressure of the steam-heat line by the throttle. When pressure to the steam-heat line is governed by the throttle, particular attention must be paid to the pressure by the engineman to prevent it from becoming excessive in the steam-heat line, which creates an element of danger by reason of the liability of the pipes to burst within the coaches and endanger the safety of passengers, in addition to the danger of steam hose bursting between the coaches.

When governing the pressure in the steam-heat line by the throttle there is no opening which could be given that would remain a uniform pressure, unless a uniform pressure was maintained in the boiler, as the pressure in the steam-heat line will fluctuate with boiler pressure.

SAFETY VALVES.

THE COALE SAFETY-VALVE AND MUFFLER.

List of Parts. The parts of the Coale safety-valve (Fig. 14) are as follows:

1B.	Base	9.	Cap for Plain Valve
2.	Spring Case	10.	Cap for Lever Valve
3B.	Modified Muffler Dome	11B.	Improved Adjusting Ring
4.	Valve	12B.	Bolt for Locking and Adjusting Ring
5.	Lower Spring Button for Relief Lever Valve	13B.	Relief Lever
		14.	Relief Spindle
6.	Lower Spring Button for Plain Valve	15.	Spring for Relief Lever Spindle
7.	Upper Spring Button	16.	Valve Spring
8.	Spring Bolt		

Description and Operation. Safety-valves are usually placed in the dome or capsen. Their purpose is to relieve any excessive pressure in the boiler, above the resistance at which they are set. When the pressure in the boiler exceeds the tension of regulating spring 16, its valve 5 is forced off its seat, allowing the steam to escape to the atmosphere, until such time as the surplus of pressure has escaped. Spring 16 will then force main valve 4 to its seat. The construction of the muffler safety-valve is so designed that it will reduce the noise of escaping steam to a minimum, which eliminates the undesirable annoyance of engines blowing off.

How to Regulate the Opening and Closing of the Valve. To regulate the Coale safety-valve, unscrew cap 9, shown

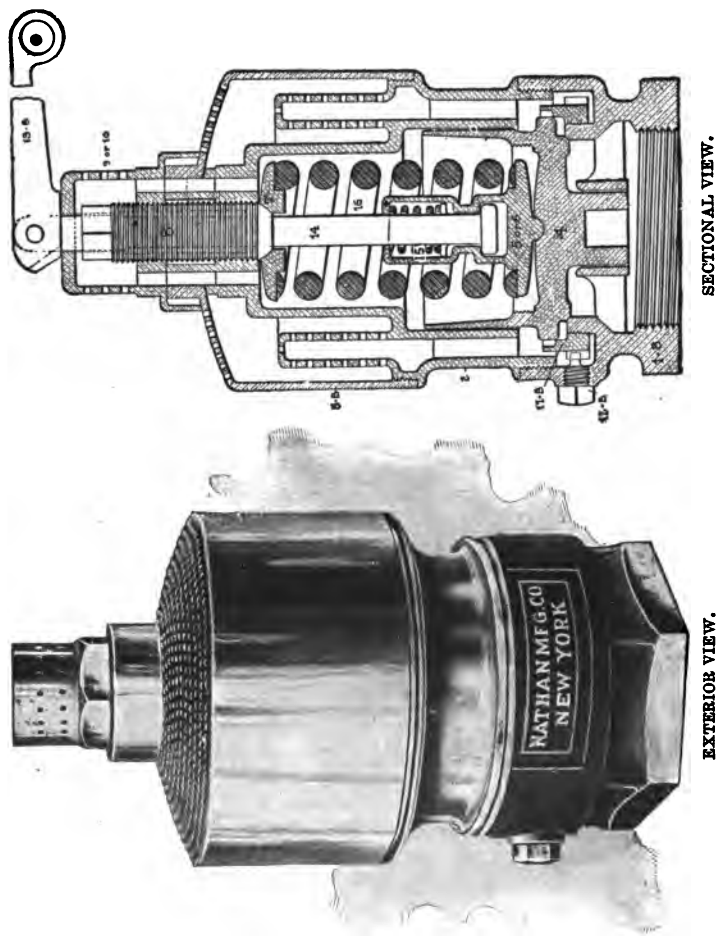


Fig. 14. The Coale Muffler and Safety-Valve.

in Fig. 14, and regulate the tension of the spring by bolt 8, according to whether more or less pressure is desired. To regulate the opening and closing of the valve, unscrew bolt 12B, and by the use of any pointed instrument the adjustable screw ring 11B may be moved either to the right or left. If the valve does not close without too much loss of boiler pressure, move the adjustable screw ring 11B to the left, one notch at a time, until the desired adjustment has been reached. To increase the discharge of steam, move the ring 11B to the right. After the valve has been adjusted, replace the bolt 12B, which must enter the notches in the adjusting ring before it can be firmly screwed into place. The omission of entering bolt 12B into the notches may affect the operation of the valve.

How to Examine the Inside of the Valve. To examine the interior of the valve and muffler, unscrew cap 9 and slack off on spring bolt 8. To relieve the tension of spring 16, unscrew dome 3 and spring casing 2, when the interior arrangement of the valve and muffler will be in plain view for examination.

Difference in Pressure of Two or More Safety-Valves Placed Upon the Same Boiler. When two or more safety-valves are used on a boiler, it is always customary and desirable to have a variation in the pressure at which they are set, which is usually from three to five pounds.

CROSBY SAFETY VALVE.

Description. The valve proper B (Fig. 15) rests upon two flat angular seats (VV and WW) and is held down against the pressure of steam by spiral spring S. The tension of spring S is obtained by screwing down on bolt L at the top of cylinder K. The difference of area between the seats W and V is that part of the valve which the steam

pressure acts upon to overcome the resistance of the spring. The smaller seat WW is not acted upon until the valve opens. The larger seat VV rests on the upper edge of the shell or body A. The smaller seat WW is located in the upper edge of cylinder chamber or valve C, which is located in the center of the shell or body of the valve, and is held in place by arms DD, radiating horizontally and connecting it with the body of the valve. These arms have passages EE for the escape of steam from the well into the atmosphere when the valve is open. This well is deepened so as to allow the wings XX of the valve proper to project into it far enough to act as guides. The flange G is for the purpose of modifying the sides of the passages EE and for turning upward the steam issuing therefrom.

Operation. When the pressure of the valve is within a pound of the maximum pressure required, the valve opens slightly and steam escapes through the outer seat into the cylinder, and thence into the atmosphere. The steam also enters through the inner seat in the well and thence through the passages in the arms to the atmosphere. When the pressure in the boiler attains its maximum, the valve is forced higher and steam is admitted into the well faster than it can escape through the passages in the arms, and its pressure rapidly accumulates under the inner seat. This pressure acting upon an additional area overcomes the increasing resistance of the regulating spring and forces the valve wide open, which quickly relieves the boiler of its surplus pressure. When the pressure within the boiler is reduced, the flow of steam in the well is reduced and the pressure diminished. The valve gradually settles down until the area of the opening into the well is less than the area of the apertures in the arms, and the valve promptly closes.

Directions for Adjusting. Adjust the head bolt L, which compresses the spring, upward for diminishing

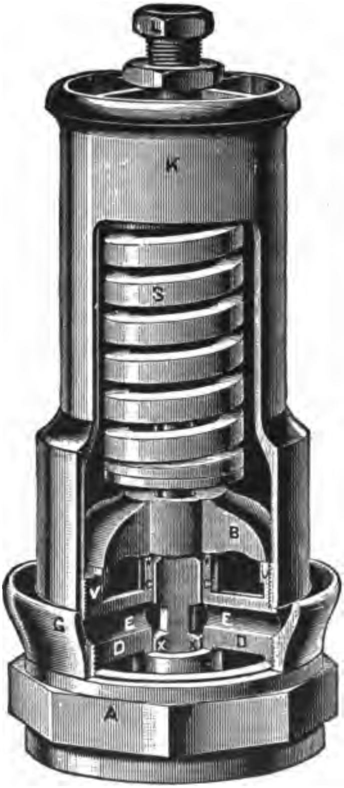


Fig. 15. Crosby's Pop Safety Valve.

pressure, or downward for increasing pressure, until the valve opens at the pressure desired, indicated by the steam-gauge. To regulate the valve for the loss of escaping steam after the surplus pressure has been relieved, turn the screw ring G upward for increasing or downward for decreasing.

General Instructions. Enginemen should never attempt to adjust or regulate safety-valves or mufflers on the road, except when the valve may have been removed for any purpose. The regulation and adjustment of the safety-valves is always taken care of at the shops by men who are assigned to this particular class of work. It is impracticable for enginemen to regulate the valve, except in emergency cases. In all cases before safety-valves are regulated the steam-gauge is tested, in order that the valve may be set at the pressure which the boiler is designed to carry. Should the engineman attempt to adjust safety-valves without knowing that the steam-gauge is accurate, disastrous results might possibly occur.

DEFECTS OF SAFETY-VALVES.

If the safety-valve adjustment spring should break, the throttle should be shut off and the dampers closed. The injectors should be put to work and as much water put into the boiler as possible, which aids in reducing the steam pressure. When the steam pressure has been reduced sufficiently to permit of working on the valve, slack off on the jam nut (if the valve is provided with one) and screw down on the spring bolt, forcing the valve rigidly to its seat. If necessary, remove the broken adjusting spring and block the valve solid to its seat, after which the jam nut should be set down solid and the opposite safety-valves set to relieve the pressure at which the defective valve worked before the defect occurred. The fire can then be built up and the engine gotten ready to proceed under full pressure.

LOCOMOTIVE STEAM WHISTLE.

Chime Steam Whistle. The Nathan type of steam chime whistle (Fig. 16) consists of an inverted metal cup or bell, usually constructed of brass. The lower edge of this bell is placed over an annular opening *aa,* from which the steam escapes and strikes the edge of bell A.

The bell of the chime whistle has three different partitions or compartments, each of which has a different depth, producing three distinct tones, pitched to first, third and fifth of a common musical scale, which harmonize and pro-

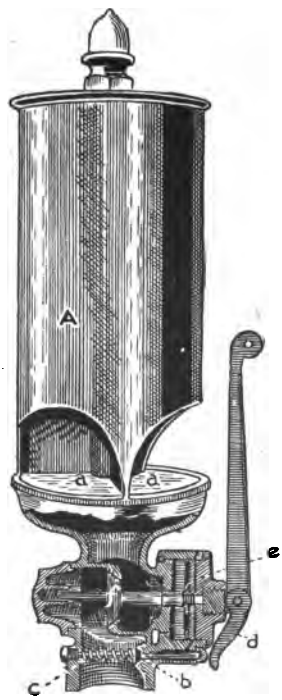


Fig. 16. Nathan Steam Chime Whistle.

duce an agreeable musical chord. This class of steam whistle is more penetrating and can be heard at a greater distance than the common whistle.

It has been found by experience that whistles used under high pressure, and they are to-day generally so used, are sounded and operated with difficulty and great exertion. To meet this difficulty, that is to sound whistles of any size, no matter what the pressure is, with little effort, this whistle was designed. The ease of operation can readily be seen by examination of the cut. The only valve which must be operated by force is the small one *b*, which is held closed by a spiral spring *c* pressed to the foot of lever *d*. A slight pull on this lever pushes inward the valve and permits steam to flow into chamber *e* and to open automatically the large valve *f* and sound the whistle. By this device the largest whistles under the highest pressure of steam are operated with ease.

LOCOMOTIVE STEAM-GAUGE.

Operation. The pressure in the locomotive boiler is indicated by an instrument known as a steam-gauge. There is a great variety of such instruments in use, which may be divided into two classes. Only the type most commonly used will be described.

The steam pressure acts on the inside of the brass tubes AB (Fig. 17), which has a tendency to straighten the tubes, thus spreading their ends, to which is attached a bent lever C, which imparts a movement to the hand D. The hand indicates on the gauge dial the number of pounds pressure which cause it to move to the position indicated on the gauge. Steam-gauges are adjusted when cold. The delicate mechanism of the gauge is adjusted to resist certain pressures and correctly indicate them when all parts are at a given temperature. The steam-pipe, which connects

with the gauge at E, should be bent in the shape of the letter S on all gauges, to permit the steam to be condensed and entrapped in the pipe, as steam pressure directly affects the elasticity of the tubes.

Care of the Steam-Gauge. Steam-gauges should be removed, cleaned and tested at regular intervals, in order that the pressure on the boiler may be properly indicated at all times.

DEFECTS.

Steam-gauges are seldom affected by defects which interfere with their operation. One of the principal defects is leakage in the pipe leading from the gauge to the boiler,

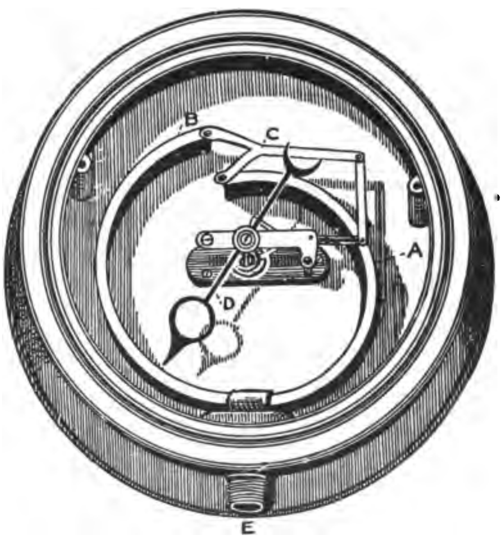


Fig. 17. Crosby Steam Gauge.

which at times becomes loose at the connection with the steam-gauge, permitting the water in the connecting pipe to escape at the leakage, which will allow steam to act

directly upon the tubes within the gauge, affecting the elasticity of the tubes to the extent that the gauge will not register correctly, but instead will indicate a higher pressure than the actual pressure within the boiler. This defect can be remedied by tightening up on the connection at the steam-gauge. In the event of the leakage not being stopped by this operation, and a gasket is used, the boiler valve should be closed, the joint disconnected, all foreign matter cleaned off the seats of the joint, or a new gasket inserted if one has been used. All joints leading to the steam-gauge should be kept tight at all times.

Another defect which occasionally occurs and causes the steam-gauge to fail to register correctly is the stopping up or clogging of the steam valve connection at the boiler, which may be clogged and cause the gauge to fail to register the correct pressure. This defect can only be remedied when there is no pressure on the boiler, and should it occur while the engine is on the road the engineman can only be governed by the safety-valve and the operation of the engine.

Other defects occurring in the steam-gauge are slight leakages in the tubes within the gauge, which cause an accumulation of vapor on the dial that obstructs the view.

GAUGE-COCKS.

The height of the water in locomotive boilers can be determined by two different appliances, which are called gauge-cocks, and the water-glass. Each locomotive is provided with three or more gauge-cocks, which are usually placed at the back end of the boiler (Fig. 18 shows an exterior and interior view of the plain gauge-cock and the manner in which it is attached) and located in a convenient place where they can easily be reached by the engineman. They are so spaced that one is three or four inches above

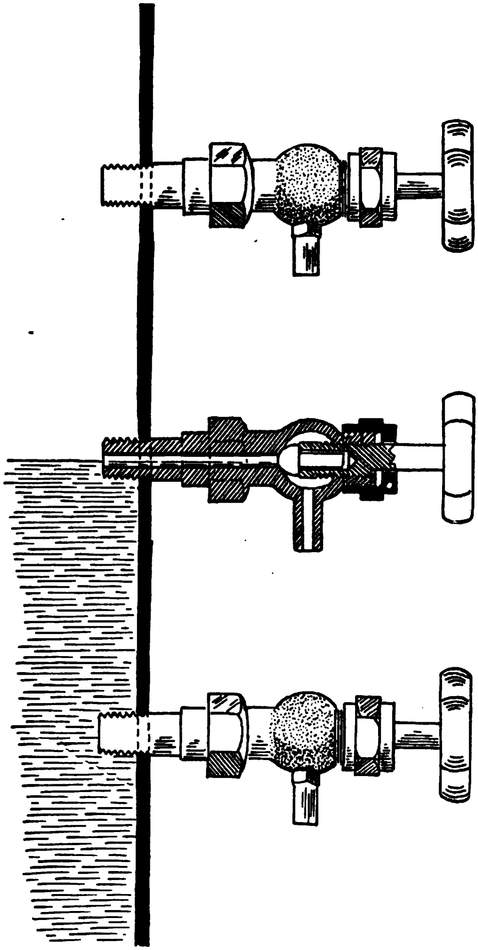


Fig. 18. Plain Gauge Cocks.

the other. The upper gauge-cock is placed at a point above where the surface of the water should be when the engine is working. The lower gauge-cock is placed below the surface of the water. The purpose of the upper and the lower gauge-cock is that the upper one connects with the steam and the lower one with the water. When these gauge-cocks are opened steam should be discharged from the upper one and water from the lower one. If the middle cock is opened it will show whether or not the water is above or below the middle cock and indicate to the engineman the actual level of the water. If the top gauge-cock is open and it discharges water it indicates that there is too much water carried in the boiler. When the lower gauge-cock is opened and steam is discharged from it, it will indicate that there is insufficient water in the boiler and that the heating surface is in danger of being exposed to the fire. If so exposed a very short time, it will become overheated, caus-

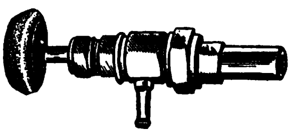


Fig. 1.
Exterior View.

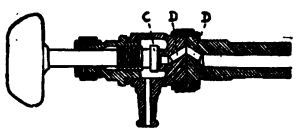


Fig. 2.
Interior View.
PLATE 19
Fig. 19. New Type Gauge-Cocks.

ing the sheets to become hot and softening the metal. The pressure being exerted on the sheets at the time is liable to force them off the stays.

Fig. 19 shows the new type or style of gauge-cock. This gauge-cock is constructed in two parts, which can be

offset, one from the other, thus closing the port openings DD, for the purpose of repacking or renewing the working parts without detaching it from the boiler while the necessary repairs are being made when the boiler is under steam pressure. When the gauge is to be offset for the purpose of making repairs, move the squares out of position and tighten up the coupling nut. This will prevent any steam or water passing to valve C, which can readily be removed.

When the necessary repairs have been completed, replace valve C, loosen up on the coupling nut and adjust the squares so that the letters OO are in line with each other. The gauge-cock can then be operated in the usual way. This type of gauge is also provided with a rubber central valve-seat, which tends to keep the cock perfectly tight and can be renewed, when necessary, in the manner previously described. Fig. 19 shows the method of construction which contains these features.

WATER-GLASS GAUGE-COCKS.

Construction. Fig. 20 shows an interior view of the water-glass gauge-cocks and glass as they are attached to the boiler. This water-gauge consists of two elbow valves, 1 and 2, communicating with each other by means of water-glass 3. The exterior diameter of this water-glass is usually about five-eighths of an inch and the thickness of the glass is one-eighth of an inch; its length varies from eight to fifteen inches.

When the water-glass is placed in the elbow valves, 1 and 2, the joints at both ends are made steam-tight by the use of rubber rings or gaskets, which are pressed tightly around the glass by means of packing nuts 4 and 5. Each elbow is provided with a valve, 6 and 7, which enables the engineman to close the valves, shutting off the steam and water from the boiler, in the event the water-glass breaks

(which is a common occurrence). The lower elbow or valve is provided with a blow-off cock, 8, through which any sediment or dirt which may collect in the glass can be blown out. When the valves 6 and 7 are opened the steam flows into the water-glass through the upper valve, and water through the lower valve, which assumes a position in the water-glass indicating the level of the water in the boiler.

If the upper water-glass cock should become stopped

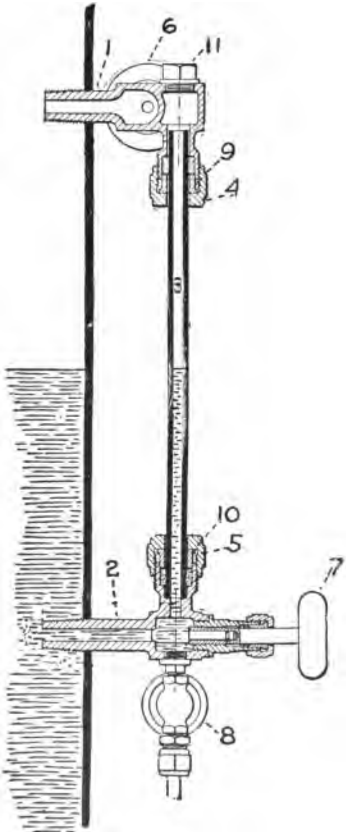


Fig. 20. Water Glass Gauge-Cocks and Glass.

up or valve closed, the steam will be shut off from the upper end of the glass. The pressure on the water in the boiler will force the water in the glass upward until the glass is filled, and it will remain in this position, indicating a full glass of water, until the water in the boiler is reduced below the lower water-glass cock, at which time the water will flow into the boiler by its own weight. Should the water in the boiler be reduced to the extent that it would allow the water to flow from the water-glass, the indication would be that the water was below the level of the crown-sheet, exposing it to the fire and causing it to become overheated.

How to Clean Out Water-Glass Cocks. The water-glass cocks which may have become wholly or partially clogged or stopped up, can sometimes be cleaned while the boiler is under steam. If the lower cock should become clogged, close the upper cock and open the blow-off cock, if one is attached. If not, remove the bottom nut on the lower cock, which will allow boiler pressure against the obstruction. There being no pressure on the opposite side of the obstruction, the boiler pressure will usually blow it out. If the obstruction cannot be removed in this manner, it will be necessary to measure the height of water in the boiler by the gauge-cocks during the balance of the trip, and the obstructed gauge-cock repaired on arrival at the terminal, where it can be bored out after steam has been blown from the boiler. The upper cock should be treated in the same manner.

Renewing Water-Glass. When putting in a water-glass, it is necessary to remove the gland nuts 4 and 5 and the follower 9 and 10, and also all broken pieces of glass and gasket which may remain in the glands of the gauge-cocks. Plug 11 should then be removed, for the purpose of inserting the glass. New gaskets should always be used, top and bottom, when renewing water-glass, and the follower nuts and glands carefully cleaned. A water-glass

of the proper length is then inserted and forced to the bottom of the stuffing-box, so that no space is open between the bottom of the stuffing-box and the water-glass. After the necessary gaskets have been applied, the gland will be forced against the gaskets and into the stuffing-box by gland nuts 4 and 5. The lower end of the water-glass should always be forced into place and held solid by the gaskets, gland and nut, before the upper end of the glass is made secure. This will prevent the gaskets and gland on the upper end of the glass from pulling the lower end of the glass off its seat, which would allow a space between the gaskets and lower end of the stuffing-box, and would allow the gaskets in the lower cock to be forced under the glass, causing it to become clogged.

Care should be taken that the glands are screwed down just enough for the gaskets to make a steam-tight joint around the water-glass. If the glands are screwed down too rigidly, they are apt to produce a strain on the glass, which would cause it to break with a slight expansion or contraction. Should a leakage occur at either end of the glass after renewal, screw the glands slightly until the leakage ceases. The engineman should always watch the water in the water-glass carefully, which will indicate any obstruction in either water-glass cock by the action of the water. The water-glass when both cocks are clear will permit the water to vibrate in the glass at all times when the engine is in motion, which is an indication that the correct level of the water in the boiler is being shown.

THE NATHAN REFLEX WATER-GAUGE.

Description and Operation. The reflex water-gauge (Fig. 21) consists of a metallic casing, designed to withstand high pressures. This gauge can be attached to all classes of boilers. Into the casing of the reflex gauge is

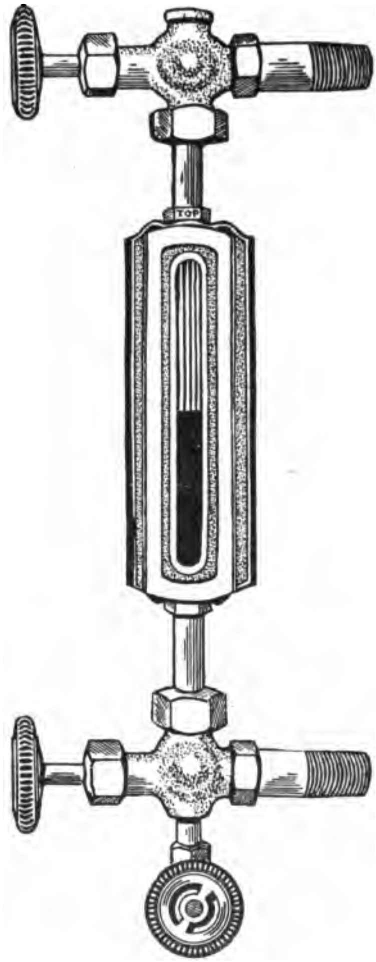


Fig. 21. The Reflex Water-Gauge, Klinger's Patent.

inserted an observation glass, measuring from one-half to five-eighths of an inch in thickness, which is of hard glass and will not fly to pieces even when subjected to sudden and marked changes of temperature. The observation glass of the reflex gauge is so arranged and shaped that it will reflect the light in that part of the gauge which contains the steam and will cause this part of the glass to become opaque and of a high luster. The light is not reflected in that part of the gauge containing the water, but passes in slight deflection to the rear of the gauge. The glass being transparent in this part of the gauge, the water will appear of a dark color, similar to the background of the casing.

When applying this gauge for the first time or after it has been removed for repairs, the bolts should be tightened uniformly as soon as the gauge becomes hot, in order that all slack which may be caused by expansion shall be taken up evenly. The tightening up of the loose parts should be repeated occasionally, as the expansion and contraction will loosen the joints and cause them to leak, which must be prevented in order to keep the glass in good working condition. Bolts should never be tightened up singly but all bolts should be tightened uniformly.

When a leak at any joint surrounding the gauge is started it should not be allowed to continue. The glass should be taken off immediately and the face joint of the frame thoroughly cleaned and the gasket renewed. Partly worn or ragged gaskets should never be used when replacing the gauge. If the gauge cannot receive attention as soon as a leak is noticed it should be closed and kept out of service until repairs are proprely made, the engineman measuring the level of the water in the boiler with the gauge-cocks. Slight abrasions or cuts in the face joint glass will first be noticed on the steam end of the gauge. This defect can often be remedied by reversing the glass; that is, placing the defective end of the glass on the water end of the gauge,

as a rule, will render the gauge serviceable for a number of trips. The chipping off of the edges or ends of the glass is of no importance so long as the face joints are in good condition.

The gauge should be blown out frequently in order to clear it of mud or other foreign matter, which would have an injurious effect on the packing and glass, as well as interfering with the proper operation of the gauge.

THE BLOW-OFF VALVE.

Construction and Operation. Plate 2 shows the Hancock pneumatic blow-off valve, consisting of brass cage 1 (Fig. 2), which has a piston 5 upon which the air acts to open the valve. The blow-off part of this valve consists of two valves, 8 and 10. Intermediate valve 8 is connected to the piston by a stem 3 and collar, which can be opened or closed by hand by means of handle 2. It also possesses the additional safety feature of an independent valve 10, which, in the event of an accident which would cause the outer casing to be broken, would retain the boiler pressure. This feature also permits the valve or outer casing 1 to be taken out for the purpose of repairs to intermediate valve 8 or piston 5, without draining the water out of the boiler. Also if the independent valve 10 fails to seat, the intermediate valve 8, which is fastened to air piston 5 by stem 3, will then seat and prevent the boiler from being drained. If the independent valve 10 and intermediate valve 8 fail to seat, a provision is made in the valve by which intermediate valve 8 can be forced to its seat by means of screw plug 2, which is attached to air piston 5. In the normal position of screw plug 2, the threads of the screw plug are flush with the thread box in casing 1, which is shown on Plate 2.

The blow-off cock is operated by air, having a pipe con-

Plate 2, Fig. 1. Hancock Pneumatic Blow-Off Valve.

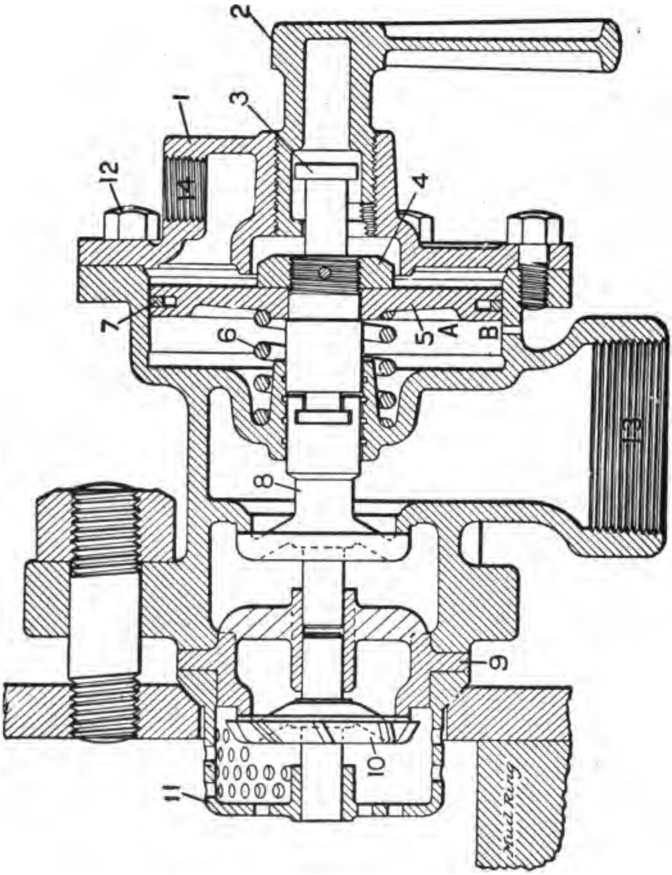


Plate 2, Fig. 2. Hancock Pneumatic Blow-Off Valve.

nection 14 extending from the blow-off cock to the cab, which admits air to piston 5, forcing the piston inward and compressing spring 6, unseating intermediate valve 8 and forcing independent valve 10 from its seat against boiler pressure, which allows the waste water to pass by boiler check and intermediate valve 8, through waste-pipe 13 to the atmosphere.

To close the blow-off cock the air-valve between the main drum and blow-off cock is closed, which allows the air to return through the same pipe into which it entered to the blow-off cock, and through vent port in the cut-out cock, to the atmosphere. The boiler pressure, forcing against independent valve 10 and intermediate valve 8, aided by spring 6, forces the valves to their seats.

The blow-off cocks are usually located near the bottom of the water-leg. Their purpose is to permit blowing out of sediment and impurities from the boiler.

When operating the blow-off cock it should never be kept open to exceed 5 or 10 seconds at a time. It should then be closed for short periods. The outward rush of water being checked, a whirling action of the water is produced, which tends to loosen up the mud and sediment which had settled on the tubes, shell of the boiler and in the water-leg. After an interval of from 5 to 10 seconds the valve should again be opened. This action should be repeated until the necessary amount of water has been drawn from the boiler. The injector should not be worked when the blow-off cock is in use, as the fresh water entering the boiler at the check tends to flow backward. The lower temperature of the water causes it to settle to the bottom, which would result in the fresh water being drawn from the boiler, instead of the foul water which is intended to be drawn out. An additional reason why the injector should not be worked when the blow-off cock is in use is that the constant influx of a large quantity of cold water would cause the boiler to cool too

rapidly, causing damage to flues, crown-sheets and stay-bolts.

Failure of the Blow-Off Valve to Close. If the blow-off cock should fail to seat or close when the air is shut off, it can be closed by screwing in plug 2, which forces the intermediate valve 8 and independent valve 10 further off their seats, which would tend to allow the obstruction in the valve to be removed by the outrush of water. The movement outward on screw plug 2 would force intermediate valve 8 to its seat, and the boiler pressure would then force the independent valve 10 to its seat, thus closing the outlet.

DEFECTS OF THE BLOW-OFF VALVE.

When the blow-off cock opens and closes while air is being admitted to the piston, the trouble is usually due to badly worn stem 3, which allows the steam and water to pass into spring chamber A. The area of piston 5 being equal, the aid of spring 6 and the boiler pressure acting on independent valve 10 and intermediate valve 8, these valves are forced to their seats. The vent port B in spring chamber A vents the steam and the water to the atmosphere. The air pressure on piston 5 opens the blow-off cock again and the operation is repeated. When the blow-off cock, after being opened, closes and will not again open until the air is shut off and again applied, the trouble may be due to the packing rings 7 being badly worn and the vent port B stopped up. The pressure on both sides of piston 5 would equalize, and, with the aid of spring 6 and the boiler pressure, the blow-off cock would close. The trouble also may be caused by a bad leak in the air-pipe connection to the blow-off cock. When the air is admitted the sudden inrush of air would strike piston 5, causing the blow-off cock to open. The leakage of air from the pipe would gradually reduce the pressure until the blow-off cock closed automatically.

When air is admitted to piston 5 and the blow-off cock fails to open, the trouble may be due to screw plug 2 being set too far outward or piston 5 stuck fast in the bushing or badly lined up between the intermediate valve 8 and independent valve 10. In freezing weather the waste-pipe may have become frozen.

LEACH "A" AND "E" SINGLE AND DOUBLE SANDERS.

Construction and Purpose. Air sanders are used for the purpose of forcing the supply of sand to the rail under the driving-wheel of the locomotive by means of compressed air, in order to prevent the slipping of the drivers. Pneumatic track sanders are now adopted as a part of the necessary equipment for the modern locomotives. The principal feature of the air sander is the economical use of sand. Its efficiency is superior to the old style lever sander. The ordinary lever sander arrangement is at times difficult to operate and is also wasteful, in addition to causing unnecessary wear of tires and train resistance, by reason of too heavy an application of sand on the rails.

There are several types of air sanders in use which operate practically on the same principle. The Leach sander being the one in most general use, the illustrations will refer to the Leach sander only.

The sand used in the air sander should be carefully screened, clean and dry. All joints and connections should be kept in good condition to prevent moisture being admitted to the sand.

Fig. 23 shows a Leach "A" single sander attached to a sand dome and its pipe connections. Fig. 24 shows an interior view of the Leach "A" type, with the names of the parts given on the cut. Fig. 25 shows a Leach "A" double sander connected to sand dome and pipe connections. Fig. 26 shows an interior view of a Leach "A" double sand trap with the names of the parts shown on the cut.

The trap receives its supply of sand through an auxiliary passage which is always open and delivers the sand into the sand pipe as is required by means of an air blast. The application of the air sander does not interfere with the arrange-

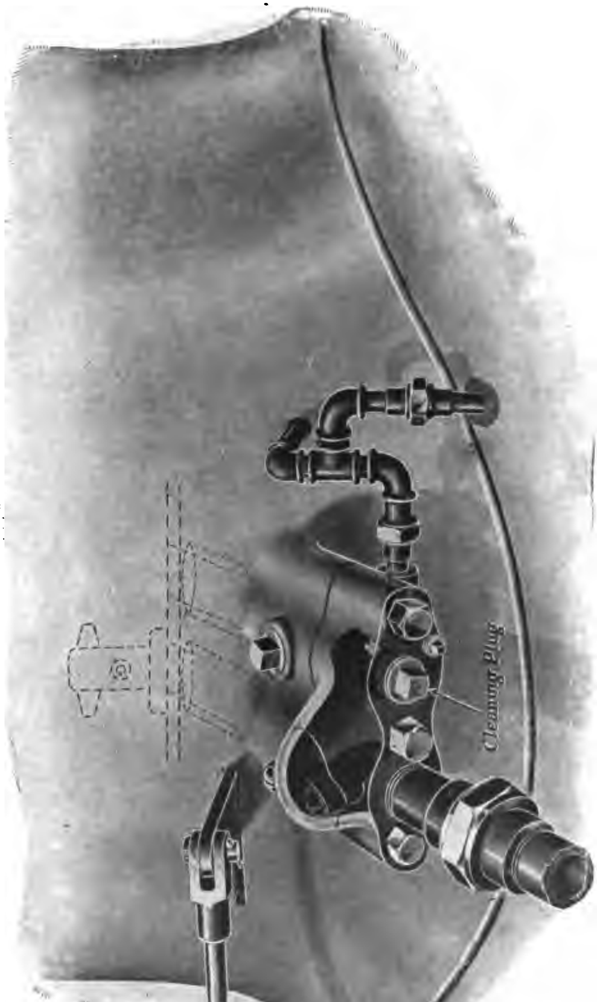


Fig. 23. Leach "A" Single Sander.

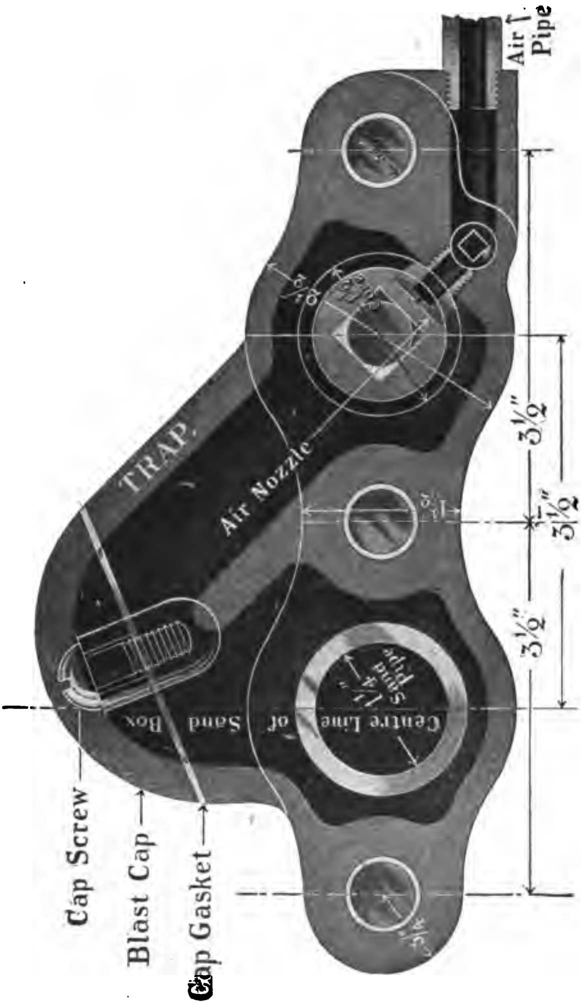


Fig. 26. Leach "A" Double Sander, Interior View.

ment or operation of the hand sand lever in any manner. Suitable arrangements and openings are provided in the trap for the removal of wet sand, gravel or other obstructions which may have become lodged in the trap. The air used for the operation of the air sander is obtained directly from the main drum, the supply being controlled by a suitable valve placed in the cab within convenient reach of the engineman. The air-pipe conveying the air to the trap is usually placed under the boiler jacket. The heat from the boiler aids in taking the moisture from the air before entering the sander.

Operation. To operate the air sander, air is admitted to the sand trap, in which is placed an air nozzle for the purpose of regulating the pressure and the sand delivery. The air nozzle is so constructed as to permit the proper amount of air to be forced through the sand pipes to the rail. The adjustment of the feed is a new feature in the air sander, as the pressure of but a few pounds at the nozzle is required for light feeding. A higher pressure would result in the waste of air and sand.

To Prevent the Unnecessary Waste of Air and Sand. In order to prevent the air-valve from being overlooked by the engineman or allowed to remain open longer than is necessary, a device, known as a "warning port," is provided in the valve or handwheel, which sounds a warning at all times when the valve is open, unless prevented from sounding by the closing of the small valve provided for that purpose. If the hand is removed from the valve, the feed continues and the warning port continues to sound until the valve is closed.

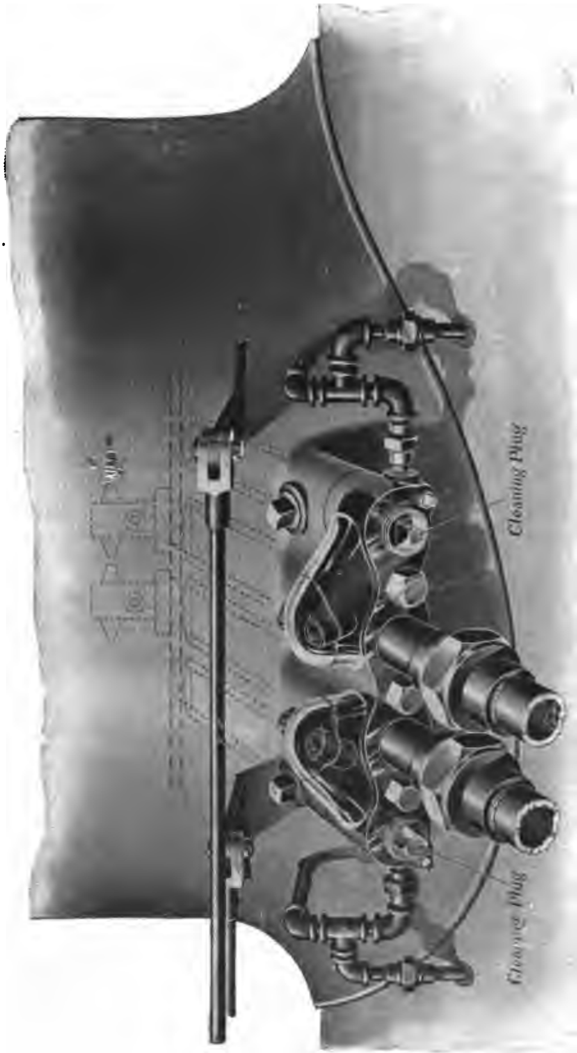


Fig. 24. Leach "A" Single Sander, Interior View.

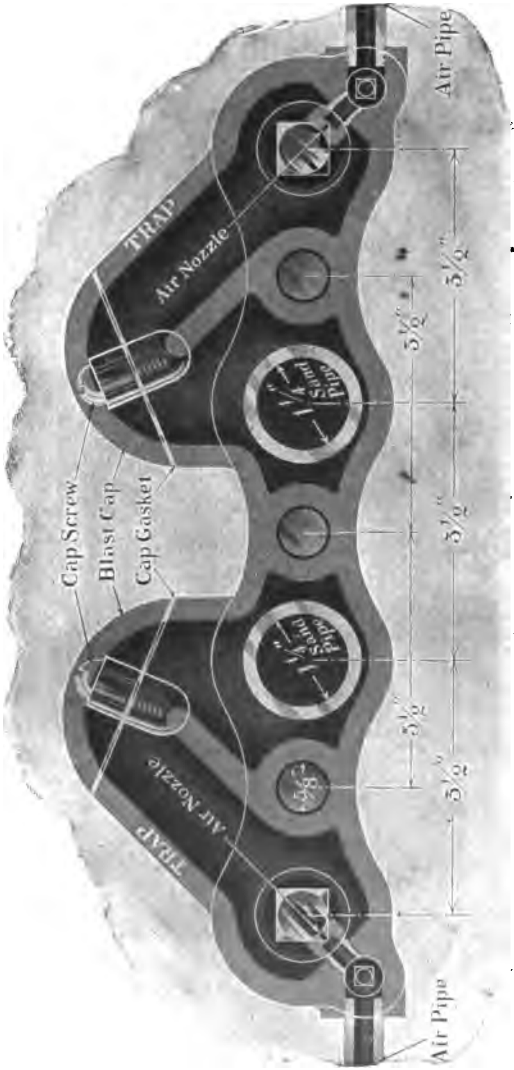


Fig. 25. Leach "A" Double Sander.

LEACH "E" DOUBLE SANDERS.

Fig. 27 shows the Leach "E" double sander as attached to the sand-box, with the pipe connections and sand trap located below the running board. The plate also shows the adjustable nozzle with the check-valve. Fig. 28 is a diagrammatic view of the Leach "E" sander as applied to the locomotive. It is located outside of the sand-box and accessible at all times for inspection or repairs when necessary. The engineman and shopman can easily observe and understand its operation and easily remedy any defects which may exist. The resistance of the volume of sand which is always above the trap prevents the air pressure from escaping upward through the sand-box to the atmosphere. Consequently a high pressure is available through the discharge pipe for removing obstructions at its lower end.

The adjustable air nozzle used with this type of sander can be so adjusted that it will regulate the amount of sand discharged to the rail. The nozzle is also fitted with a small check-valve which prevents the air passages from becoming clogged with sand. The discharge pipe is bent upward at an angle of about 45° to prevent the sand from working out of the trap when the engine is in motion. A cleaning plug 2 is placed in the lower part of the trap for the purpose of removing wet sand or any other obstruction which may lodge in the trap.

Regulation of Sand Delivered. To regulate the amount of sand to be delivered to the rail it is necessary to increase or decrease the space 3 between the end of the nozzle and the discharge pipe, by loosening jam nut 4 and moving the adjusting nozzle 5 inward or outward as desired. The greater the distance between the nozzle and discharge pipe 3, the greater amount of sand will be delivered.

Care should be taken to adjust the nozzles on the oppo-

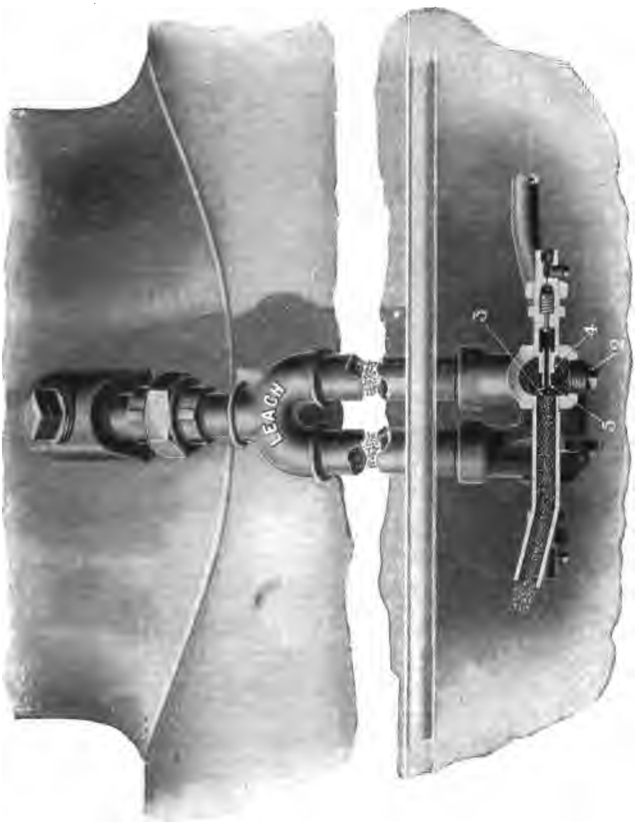


Fig. 27. Leach "E" Double Sander.

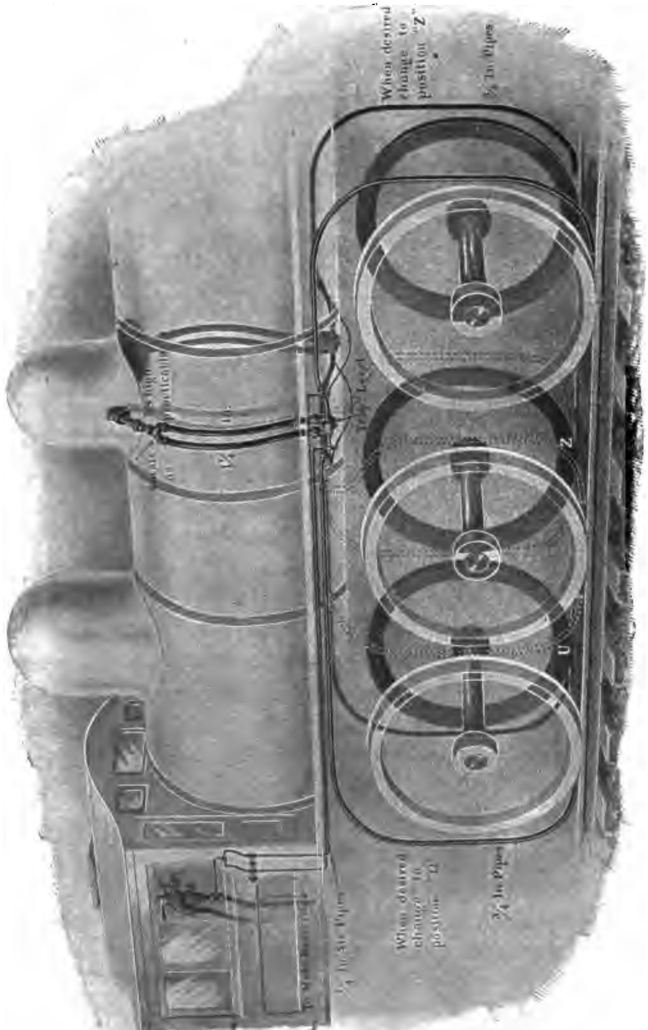


Fig. 28. Leach "E" Sander.

site sides of the engine to correspond with each other, in order that the volume of sand delivered to the rails on each side of the engine will be equal.

When more than one delivery pipe is connected to a single trap, provisions are made for preventing the sand and air from escaping through the channel with the least resistance. This is prevented by the construction of a trap with a separate compartment for each delivery pipe and having a column of sand in each compartment so that the air and sand in one trap cannot cross from one to the other.

Care of Delivery Pipes. Care should be taken to clamp the delivery pipes rigidly at the bottom. The pipes should be bent at an angle so that the sand will be delivered directly to the point of contact between the driving wheels and the rails.

DEFECTS OF THE AIR SANDER.

If the sand fails to appear at the sand-pipe after the air has been admitted, it should first be ascertained whether or not there is sand in the sand-box. If the supply of sand is sufficient, the trouble may be due to the delivery pipe becoming clogged, a trap stopped up, a leak in the air-pipe preventing the air from reaching the trap, or the adjusting nozzle becoming clogged.

To locate the trouble, first open the air-valve in the cab, noting whether or not air is escaping from the delivery pipe. If so, it indicates that the pipe is clogged in the dome. Plug 6 should then be removed and a wire inserted to remove the obstruction. If no air appears at the delivery pipe it indicates that the trap is clogged, there is a leak in the air-pipe, or a clogged nozzle. To determine whether or not the air is admitted to the sand trap, thumbscrew or plug 7 should be removed. If a full blast of air escapes from the opening, it indicates that the air has reached the trap. Plug 2 should then be removed and the trap thoroughly

cleaned, and the air again turned on. Care should be taken to observe as to whether the air passes through nozzle 5. When dry sand appears at the trap, plug 2 can again be replaced. If the delivery pipe is clogged, it can be opened by tapping it lightly with a hammer. In freezing weather it may be frozen, under which circumstances it would be necessary to thaw it out before sand could be admitted to the rails.

THE GOLLMAR AUTOMATIC BELL-RINGER.

Construction and Operation. An automatic bell-ringer is one which is operated by compressed air. Fig. 1, Plate 3, shows the interior view of the automatic bell-ringer and Fig. 2 the manner in which it is attached to the bell.

There are two openings into the cylinder, the upper being the inlet, the lower the exhaust port B. Air pressure is admitted through the upper opening A. The operation of valve 43 through which a hole is drilled, admits the pressure under the single acting piston 39, which has a stroke of 1¼ inches when at its extreme travel. Crank 31 has a stroke of 4 inches. The connecting rod is in two sections, 35 and 36, which will allow crank 31 to make a complete revolution without causing piston 39 to move.

When the ringer is started to work, piston 39 will be driven upward, causing the bell to swing. Valve-stem 42 will raise valve 43, closing the inlet port and using the pressure expansively by traveling the length of the lap before it will open the exhaust port. The bell having received an impulse, will continue its motion after piston 39 has reached the upper end of its stroke, the crank box 35 sliding on rod 36. The impulse which the bell received being expended, it will return to its normal position by its own weight; the governor bolt 33 will strike the end of rod 36, which will force piston 39 downward, coming in direct

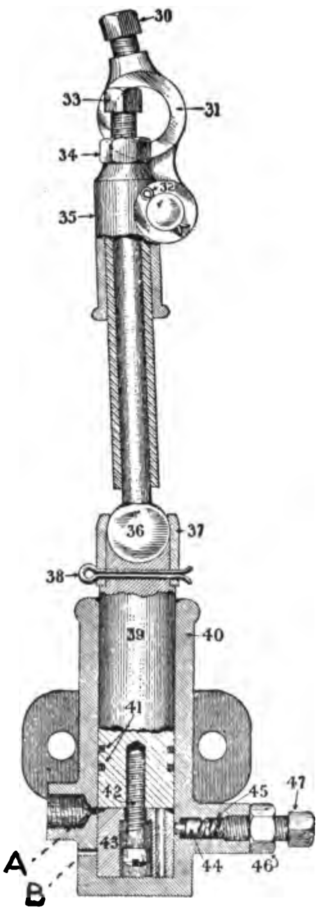


Fig. 2.

Fig. 1.

Gollmar Bell Ringer, Plate 3, Figs. 1 and 2.

contact with valve 43, and closing the exhaust port and opening the inlet port, after cushioning on the pressure remaining under piston 39, after the exhaust is closed. It will be noted that valve 43 is operated only at the termination of the piston stroke.

This bell-ringer can be adjusted to use pressure in proportion to the stroke required. The adjustments are made by means of valve-stem 42, which is secured in its various positions by a pin. No change in the length of the connecting rod is required in changing the adjustment. The valve adjuster 44 and spring 45 are adjusted in such a manner as to keep valve 43 in contact with the side of the cylinder in which the inlet and exhaust ports are placed, so that there can be no leakage from one to the other, and a positive cut-off is assured.

DEFECTS OF THE BELL-RINGER.

When air is admitted to the bell-ringer and the valve fails to start, it may be caused by the admission port being stopped up; the valve not having sufficient lift; crank 31 may be on the dead-center, which would prevent piston 39 from being forced upward and exerting its power on the bell; packing rings 41 may be broken, which will allow the air to escape to the atmosphere as fast as it is admitted to the cylinder; too great or not enough lift between the upper piston 39 and lower valve 43; the bell-crank may have become loosened on the shaft, or the parts may be improperly adjusted.

When the piston raises and lowers a number of times during the stroke of the bell, it is caused by badly worn packing rings 41, which allows piston 39 to drop, and striking the lower valve, causes it to move down. This movement again admits air to piston 39 before the bell has returned to its normal position. When the bell continues

to make complete revolutions when in operation, it would indicate improper adjustment of the governor. To remedy this defect, slack off on governor bolt 33, until the bell will make its stroke properly without revolving. Then tighten jam nut 34.

When the air is admitted to the bell-ringer and there is not enough force or power to move the bell upward, slack off on jam nut 34, and screw down on governor bolt 33. This operation will lengthen the rod, and, if it is not sufficient to cause the bell to move, will lengthen valve-stem 42. This will give piston 39 additional power to lift the bell before the air supply is cut off.

LOCOMOTIVE LUBRICATORS.

NATHAN TRIPLE SIGHT FEED LUBRICATORS.

List of Parts.

1	Condenser	10-a	Upper Sight Bracket (Air Brake)
2	Filling Plug	11	Lower Sight Bracket (Cylinder)
3	Auxiliary Oiler (Cylinder)	11-a	Lower Sight Bracket (Air Brake)
3½	Auxiliary Oiler (Air-Brake)	11-b	Sight Glass Packing Nut
4	Safety-Valve	12	Body
5	Reducing Plug	13	Gauge-Glass Plug
5-a	Blow-Off Plug	14	Gauge-Glass
6	Delivery Nut and Tailpiece (Cylinder)	15	Upper Gauge Bracket
6-a	Delivery Nut and Tailpiece (Air-Brake)	16	Lower Gauge Bracket
7	Water-Valve	17	Waste Cock
8	Stud Nut	18	Regulating Valve
9	Sight Feed Glass	19	Bottom Plug
9-a	Feed Nozzle	20	Top Connection
10	Upper Sight Bracket (Cylinder)	21	Equalizing Pipe
		22	Oil Pipe
		23	Water Pipe
		24	Center Body Plug

Construction and Operation. Fig. 1, Plate 4, shows a front view of the Nathan Triple Sight Feed Lubricator. Fig. 2 shows a side view, and also the manner in which the lubricator is fastened to the boiler head bracket by nut K. E is the condenser to which steam is conducted by the copper tube G, leading either from the dome or the top of the boiler and connected to a dry pipe leading

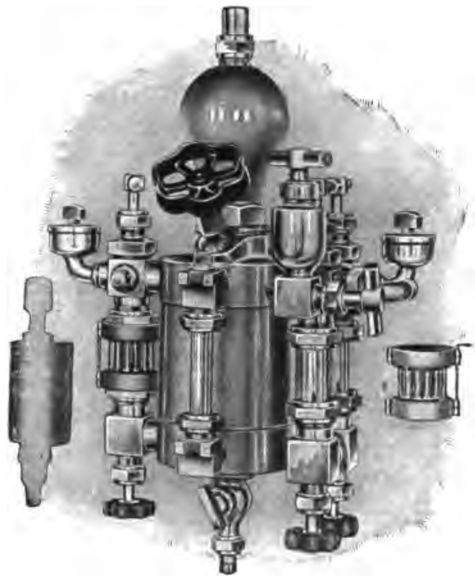
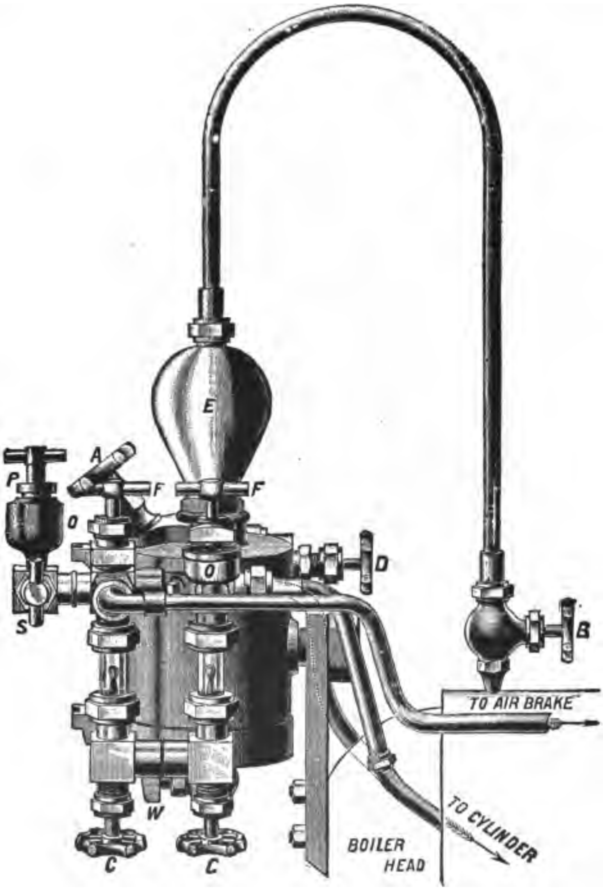


Plate 4, Fig. 1.

to the dome. B (Fig. 2) is a steam valve for controlling the supply of steam to the lubricator; A is the filling plug, which is removed when the lubricator is filled. Auxiliary oiler O is provided for each cylinder, independent of the lubricator, and can be used to carry the oil to the cylinder if the feed glass breaks or other defects exist in the lubricator which would cause it to become inoperative. Each sight feed glass J is pro-

vided with a safety-valve F, so that if the feed glass breaks, the safety-valve F and the regulating valve C can be closed to prevent the oil and steam from escaping.



SIDE VIEW.

A. FILLING PLUG. B. STEAM VALVE. C. C. C. REGULATING VALVES.
F. F. F. SAFETY VALVES. O. O. O. AUXILIARY OILERS. W. WASTE COCK.

Plate 4, Fig. 2.

HH are the oil pipes leading from the oil outlets of the lubricator to the right and left cylinder and steam chest; I is the oil pipe leading to the steam end of the air-pump;

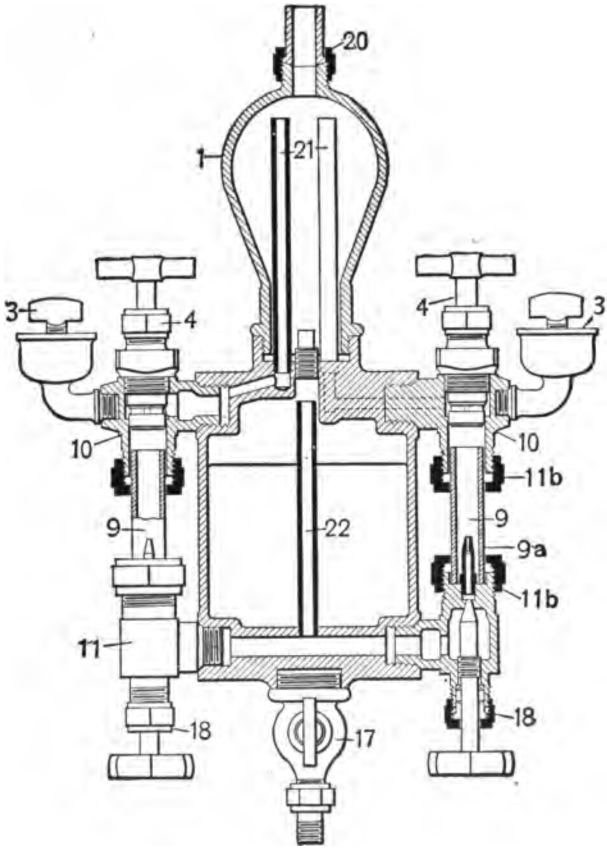


Plate 5, Fig. 1.

D is the water-valve which controls the passage from the condenser E to the oil reservoir 12 (Plate 5, Fig. 2); 14 is the glass-gauge which registers the amount of

oil and water in the lubricator; W is the waste cock for drawing off the water from the oil reservoir; CC are the

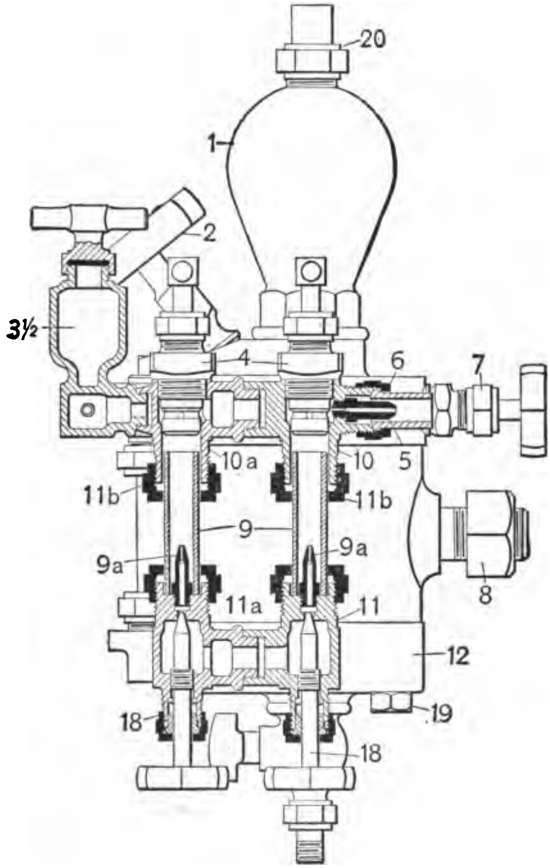


Plate 5, Fig. 2.

regulating valves for regulating the supply of oil to the valves.

Four sectional views are shown in Plate 5. Fig. 1 shows a front section; Fig. 2, a side view; Fig. 3, a par-

tial side view and Fig. 4 a top sectional view. Inside of the condenser are three equalizing tubes 21 (Figs. 1 and 4), two for the cylinders and one for the air-pump. These

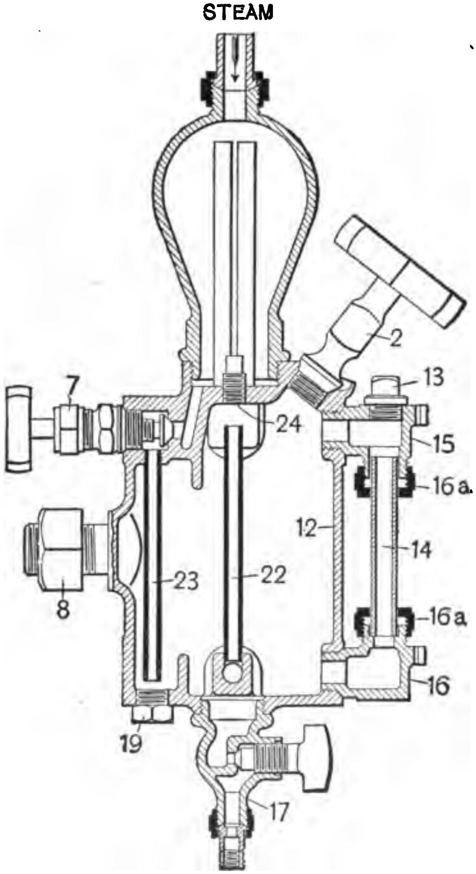


Plate 5, Fig. 3.

tubes are open on the top, and the lower end of each is connected to a passageway leading to the sight feed glasses.

The steam passes through these equalizing tubes and maintains a uniform pressure on the water in the sight feed glasses. Any surplus water in the condenser is free to pass through the equalizing tubes to the sight feed glasses, thus filling them up with water. The condenser is connected with the oil reservoir (Fig. 1) through a passage and water-valve 7 and water-tube 23. The lower

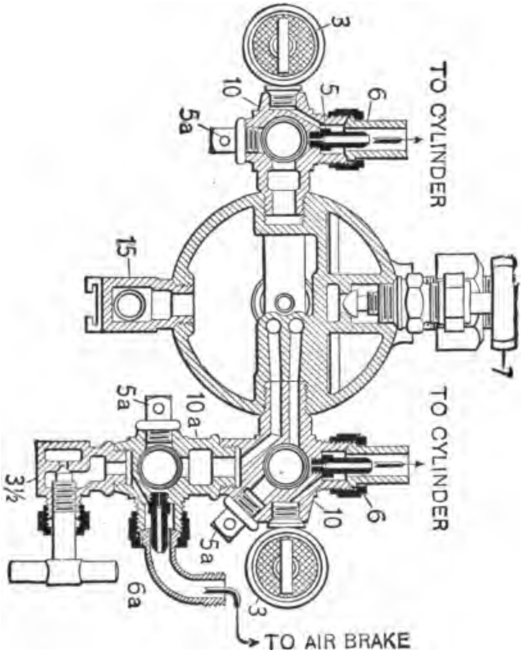


Plate 5, Fig. 4.

end of this tube opens into a pocket in the bottom of the oil reservoir, as shown in Fig. 2. When the water is drawn off through cock 17, this pocket remains full of water. As the lower end of tube 23 is below the surface

of the water in the pocket, the oil cannot rise in the tube when the reservoir is being filled. An additional pocket known as the air pocket is situated in the upper part of the oil reservoir (Fig. 2).

When the reservoir is being filled, the oil rises until it reaches the bottom of the pocket, and the air which is entrapped in the pocket prevents the oil from occupying that space when the reservoir is filled, which allows for the expansion of the oil after it becomes heated. If this air space were not provided, and the water-valve and regulating valves were closed, the force exerted by the expansion of the heated oil would be sufficient to bulge or burst the reservoir.

Oil tube 22 is open at the top and is in communication with reservoir 12. The lower end of oil tube 22 is connected with the oil passages which lead to the under sides of each of the regulating valves 18. The oil tube and passages are filled with oil as long as there is any oil remaining in the reservoir.

Condenser 1 is about two-thirds full of water when the lubricator is in operation; all surplus water from condensation passes out through the steam tubes to the oil pipes. Also when water-valve 7 is open, the water can pass down through a passage past valve 7 and down tube 23 to the bottom of the oil reservoir.

The oil floats on the surface of the water and is forced by the weight of the water and the pressure of the steam acting upon it in the condenser, upward, and then down oil tube 22 and into the passages leading to regulating feeds 18. Steam and water continue to flow down equalizing tubes 21 to the sight feed glasses 9 (Fig. 1), filling them with water. When regulating valve 18 is opened the oil forms in drops, passes through the water in the sight feed glasses 9 to the reducing plugs, and is there met by a jet of steam from the equalizing tubes, and the

oil is forced through reducing plugs 5 and the oil pipe to the steam-chest. As fast as the oil escapes from the reservoir its place is filled with the water from the condenser.

Safety-valves 4 are for use only in case of the breakage of a feed glass. In this event safety-valve 4 and regulating valve 18 should be closed. Auxiliary hand oiler 3 can then be used until the broken glass can be renewed. The breakage of any one glass and the closing of the safety-valve and regulating valve 18 will not interfere with the operation of the other feeds.

Both steam valve B (Fig. 2, Plate 4) and water-valve 7 (Fig. 3, Plate 5) should always be opened before a locomotive leaves the roundhouse, whether the feeds are in operation or not. This will serve as an additional precaution against the expansion of the oil endangering the reservoir. If water-valve 7 is open, the oil will pass up into the water-tube 23 and into the condenser 1, and prevent any possibility of damage to the lubricator if the reservoir were too full of oil.

Steam valve B is the first valve to be opened when starting, and the last one to be closed when shutting off the lubricator. To start the feeds, regulating valve 18 should be opened and regulated until the desired number of drops per minute are being fed to meet the requirements of the valves.

The oil reservoir and the sight feeds should be blown out at least once a week. To clean the lubricator and sight glasses the regulating valves should be opened wide, after which the water-valve, steam valve and drain plug 17 should also be opened. This will allow the sediment in the feed glasses and the passages to be blown into the body of the lubricator and thence out through drain plug 17.

DEFECTS AND REMEDIES.

If one of the feed valves becomes stopped up, it should be cleaned out by closing the regulating valves on the other feeds, and also closing water-valve 7. Then open drain cock 17 and allow some of the water to be drained off to make room for the oil in the passages, and the water in the sight feed glass to be forced into the oil reservoir, permitting the sediment to settle to the bottom of the reservoir. This will eliminate the necessity of entirely draining the reservoir of its contents. The regulating valve should be closed until the feed glass is filled with water, after which the feed will work properly. As soon as the drain cock is closed, the water-valve should be opened and the other feeds may then be started.

To put in a new lubricator glass when one has been broken, all valves should be shut off and the lubricator drained. Remove the upper side bracket and nut 10. The broken parts of the glass and old gaskets should then be removed, and new gaskets inserted. Replace the side bracket and nuts sufficiently to hold them, and then insert a new glass of the proper length, forcing it down to its place by the aid of a piece of wood. The lower nut should first be tightened, the upper nut then tightened and gauge-glass plug 13 replaced.

BULL'S EYE LUBRICATORS.

It was long ago realized that in the design of all lubricators in use up to a recent date there were certain inherent defects which it was necessary to remove before a satisfactory solution of the lubricator question could be reached.

With the increased steam pressure used on modern

locomotives conditions arose which proved that the lubricators then in use were practically unfit for the service for which they were intended. This was evidenced by the breaking of glasses, resulting in injuries to enginemen, cutting valves, failure to make time schedules, leaky joints, increased cost of maintenance, and other troubles of such variety as to affect the successful operation of the locomotive.

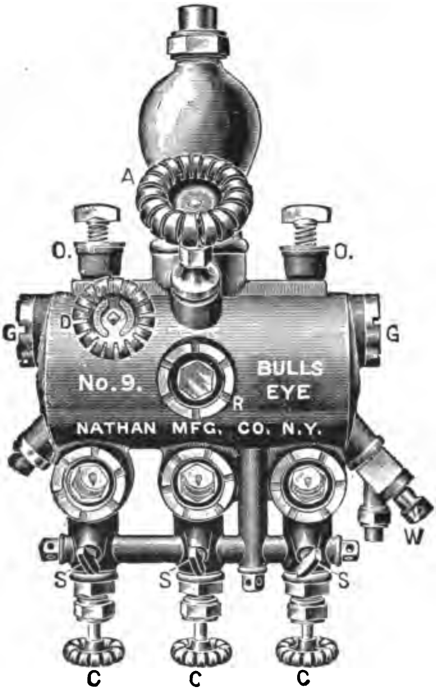
By careful study of the entire situation, as well as of the lubricator then in use, it became evident that a radical change in the construction of the lubricator was imperative. In making the changes in the old style lubricator it was apparent that the danger and defects should be eliminated. The changes made have been the result of careful and thoughtful study and have produced the "Bull's Eye" pattern of the lubricator.

NATHAN TRIPLE SIGHT FEED "BULL'S EYE" LUBRICATOR.

List of Parts.

1. Condenser
2. Filling Plug
3. Hand Oiler
5. Reducing Plug
6. Delivery Nut and Tailpiece
7. Water-Valve
8. Stud Nut
9. Sight Feed Glass and Casing
9-a Feed Nozzle
11. Body
13. Gauge-Glass and Casing.
14. Waste Cock
15. Regulating Valve
16. Top Connection
17. Equalizing Pipe
18. Oil Pipe
19. Water Pipe
20. Sight Feed Drain Valve
21. Reverse Glass and Casing

22. Cleaning Plug
23. Body Plug
24. Oil Pipe Plug
28. Gauge-Glass Bracket
29. Cleaning Plug
30. Gauge-Glass Cap



FRONT VIEW.

Plate 6, Fig. 1.

Construction and Operation. Plate 6, Fig. 1, shows a front view and Plate 6, Figs. 2, 3, 4 and 5 sectional views of the modern "Bull's Eye" lubricator, Nathan type. This instrument is made to withstand the increased steam pressures used on modern locomotives, and it may be safely relied upon under all conditions of service. Instead of the tubular glasses heretofore used, this type

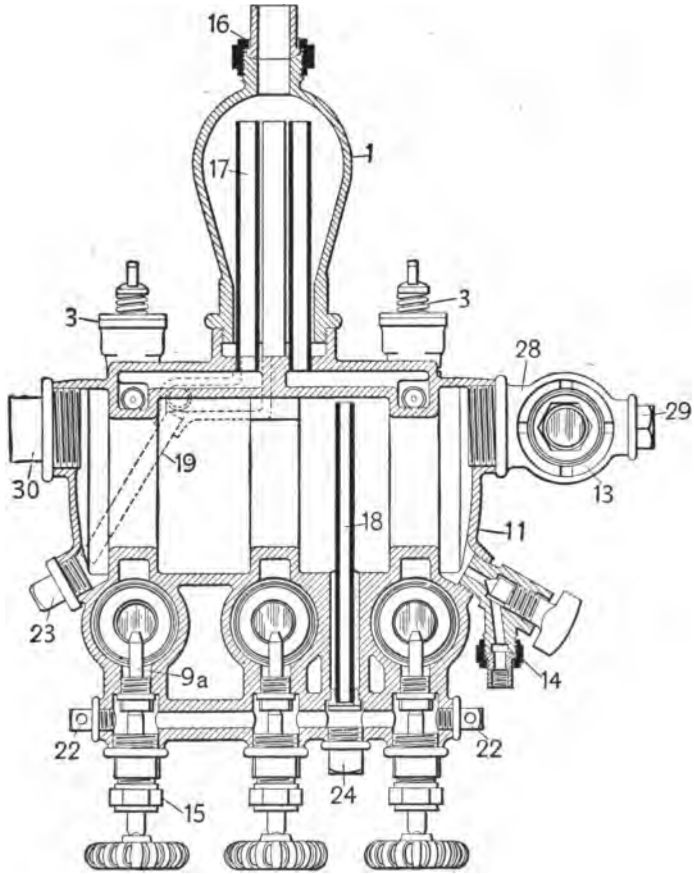


Plate 6, Fig. 2.

of lubricator is equipped with a new form of disk glass, which will not break under any condition of service. All the danger to enginemen and delays to trains resulting from the breaking of glasses in service have been eliminated. The construction has also been simplified in other ways. There are no brackets to become loose,

causing bad leakage and breakage of glasses. The lubricator also carries a reserve glass packed in a casing provided for that purpose in front of the lubricator, ready for use when needed. All glasses are packed in casings, which screw into the body of the lubricator, making their

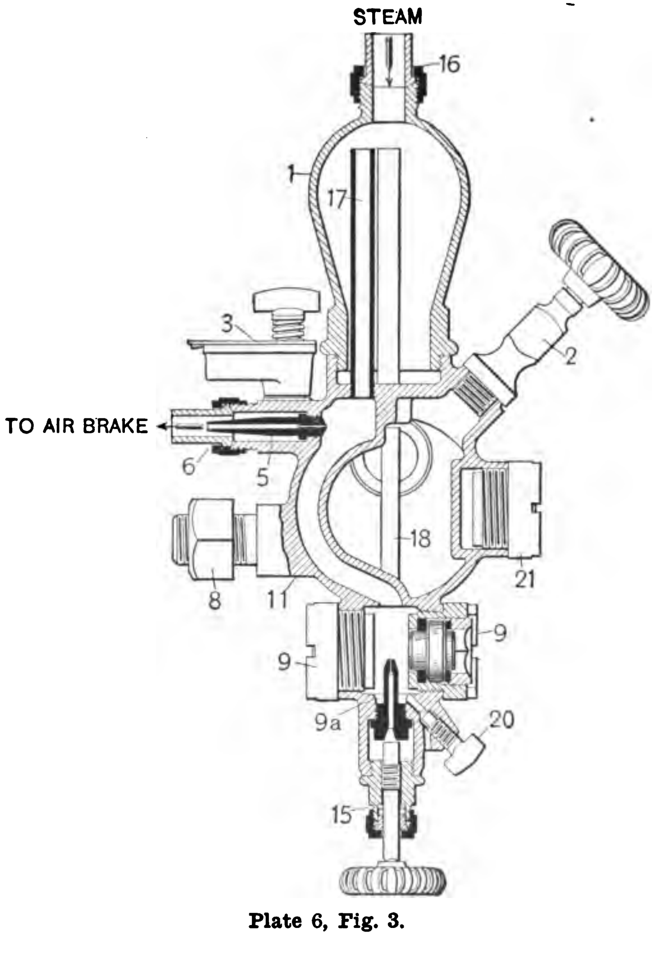


Plate 6, Fig. 3.

removal for inspection or repairs more convenient than with other styles.

The cylinder oil outlets of this lubricator are provided with reducing plugs 5, of a specified bore, the importance of which lies in the relative proportion of their interior

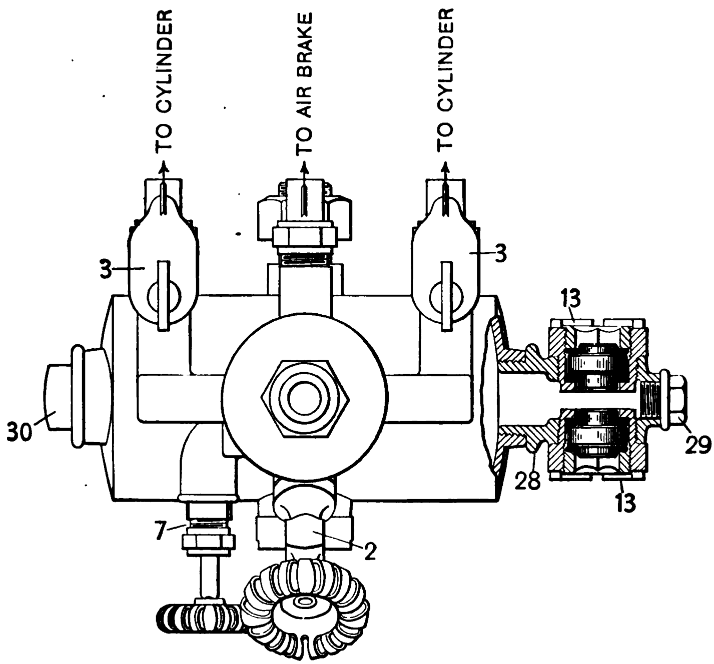


Plate 6, Fig. 4.

diameter to the reduced openings at the steam-chest. The oil pipe must be provided at its steam-chest connection with a choke of not less than three thirty-seconds, or more than one-eighth of an inch in diameter. The choke at the steam-chest is necessary for the proper operation of the lubricator. (Fig. 5, Plate 6.)

How to Clean Lubricator. To clean the lubricator,

water-valve 7 should be shut off, waste cock 14 opened, and the lubricator drained of its contents. All feeds should then be opened, cleaning plug 22 removed, and water-valve 7 and steam valve given their full opening. Steam would then pass down through equalizing tubes 17, forcing the contents out of the sight feed glass 9, through the feed nozzle 9-a and regulating valve 15, into

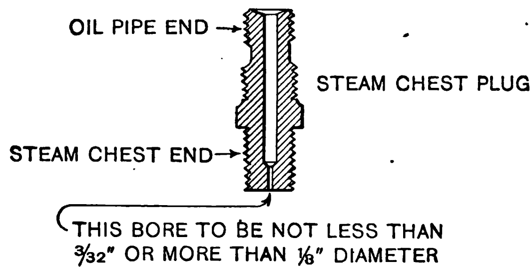


Plate 6, Fig. 5.

the oil channel and through the opening of cleaning plug 22.

To blow out oil pipe 18, all regulating valves 15 and waste cock 14 should be closed, and oil pipe plug 24 removed, which will allow the steam to pass directly through the oil pipe to the atmosphere. To blow out water pipe 19, body plug 23 should be removed and water-valve 7 opened. To clean the gauge-glass, remove cleaning plug 29 and open steam valve and water valve 7. To clean reducing plug 5, or a sight feed glass which has become filled with sediment, regulating valve 15 should be shut off, and the sight feed drain opened, which will allow the steam from the equalizing tube to remove all foreign matter. The same result may be accomplished by opening the engine throttle, allowing steam to back up and through the reducing plugs 5, down and by the sight feed glass and out of drain valve 20.

The manner of filling this lubricator and putting it into operation is the same as with other types of Nathan lubricators.

Replacing Glasses. Replacing glasses is more easily accomplished with this type than with others. The follower should first be removed, next the washer, and then the glass and gasket. When replacing the glass, the gasket should first be put in place, then the glass, and next the washer and the follower.

Plate 7, Fig. 1, shows a reserve glass packed in its casing ready for use when required. If a glass breaks the old casing should be removed and replaced by the

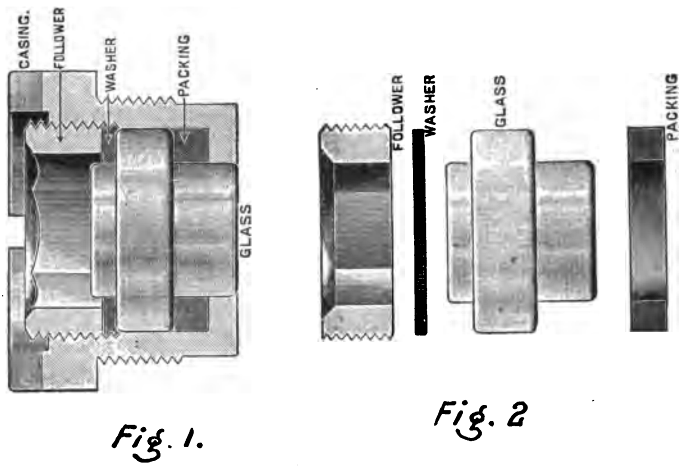


Plate 7, Figs. 1 and 2.

extra one. After slightly tightening up the follower, the glass is ready for use.

Fig. 2 shows packing, glass, washer and follower as they appear when put in their respective places in casing, shown in Fig. 1.

THE "CHICAGO" THREE-FEED LUBRICATOR, BULL'S EYE TYPE.

List of Parts.

4. Check-Valve
6. Pipe Union Nut for Steam-Chest Circulating Pipe
7. Pipe Union Nut for Air-Pump Circulating Pipe
8. Steam Supply Union
9. Steam Supply Nipple
10. Cap Plug for Pipe T
23. Filler Plug
24. Handle for Valve-Stem
30. Feed Valve Packing Nut
31. Feed Valve
33. Drain Valve
34. Drain Valve Plug for Oil Bowl
35. Tallow Pipe Union
36. Choke Plug for Air-Pump Feed.
55. Cap for Steam-Chest Valve
56. Casing for Steam-Chest Valve
57. Valve for Steam-Chest Valve
62. Pressure Valve and Nut
63. Cap Plug
64. Pipe Plug
65. Auxiliary Oil Cup
66. Auxiliary Oil Cup Filler Plug
67. Cap Plug
68. Oil Pipe Bushing for Air-Pump Feed Supply.
69. Packing Nut for Glass.
70. Follower Ring and Washer for Solid Glasses
71. Condenser
72. Oil Bowl
73. Water-Valve Complete
74. Pipe Connecting T
75. Connecting Nut for No. 74
76. Ball Joint for No. 74
77. Feed Valve Hub
78. Auxiliary Oil Cup Feed Valve Complete
79. Pressure Valve Hub
80. Solid Glasses for Feed Pocket or Index
81. Feed Tip
82. Circulating Pipe Complete for Air-Pump
83. Circulating Pipe Com-

plete for Steam-Chest

84. Pipe Hub Air-Pump and Low Pressure Circulating Pipes

85. Pipe Hub for Steam-Chest Circulating Pipe

88 Auxiliary Oil Cup Drain Valve

89. Gaskets for Solid Glasses

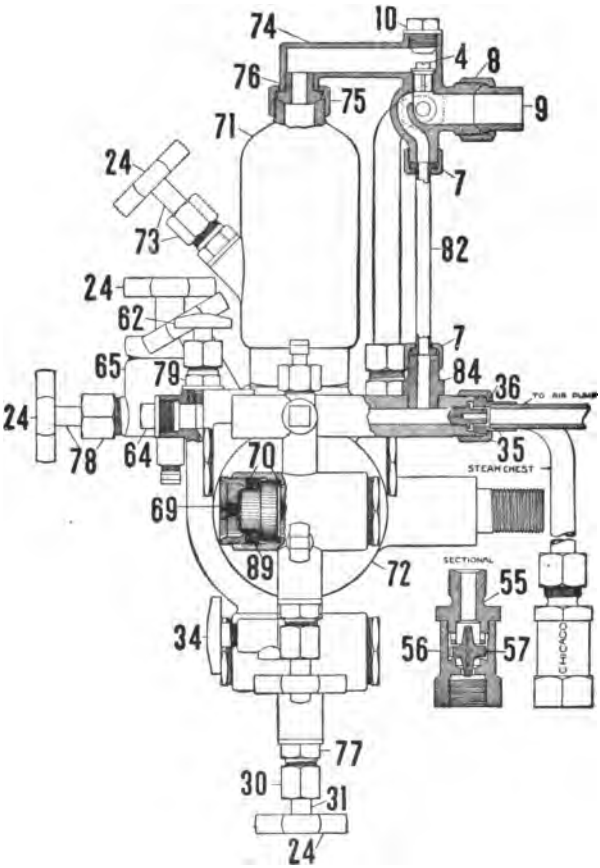


Plate 8, Fig. 1.

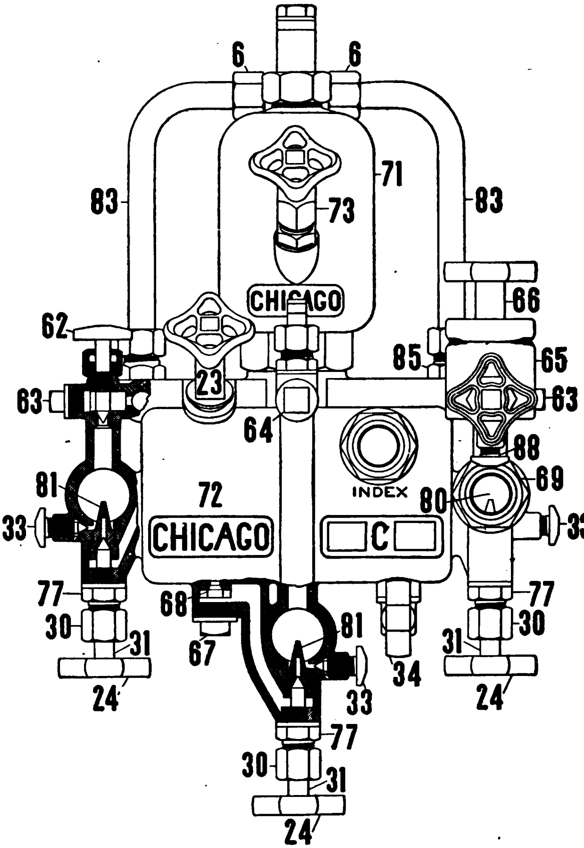


Plate 8, Fig. 2.

Construction and Operation. Plate 8 shows two sectional views of the "Chicago" three-feed lubricator "Bull's Eye" type. The feeds are independent of each other; any one of them may be shut off to renew gaskets or make other repairs without interfering with the other feeds, by closing pressure valve 62 and feed valve 31 and opening drain valve 33.

The oil supply for each feed valve is separate, dispensing with the one oil pocket for all feeds which is usually found on other lubricators. There are no inside pipes to leak or get out of order by reason of sand holes and other defects in the casing. All pipes for steam circulation are placed outside and convenient for repairs in case of steam leaks or other defects.

The arrangement of pipes shown in Figs. 1 and 2, Plate 8, is such that an intense heat is never produced in the condenser. This prevents any loss of the lubricating properties of the oil, which would occur if the oil were heated to a high temperature.

Pressure valves are used to protect the engine crew in the event of a broken glass or of a gasket blowing out. The oil is delivered to the engine valves regularly under all conditions of service or steam pressure.

The feed is regular at all times and under all conditions and will not vary unless there is an obstruction in the pipes or passages of the lubricator. It will not siphon the oil out of the lubricator, this feature being prevented by check-valve 4, which is interposed between the steam supply and the condenser.

The auxiliary oil cup 65 is a pressure cup and is in direct connection with the oil pipe through the upper feed arm and over the seat made by pressure valve 62, and can be filled and operated without closing the engine throttle or the lubricator steam valve.

The five-feed lubricator is especially designed for use on balanced compound and other compounds where more than three feeds are required. It is equipped with five oil pipe connections and feeds and occupies only the space required for a three-feed lubricator.

DETROIT No. 21 LOCOMOTIVE LUBRICATOR, BULL'S EYE TYPE.

List of Parts.

1041 1-inch Tailpiece
1314 Feed Stem Ring
1618 Steam Valve Packing Nut
1621 Steam Valve Disk Lock-Nut
1623 Steam Valve Gland
1754 1-inch Tail Nut
2076 Feed Valve Gland
2082 Tailpiece
2083 Tail Nut
2084 Vent Stems
2085 Support Arm Jam Nut
2087 Feed Valve Stem Nuts
2105 Drain Stem
2107 Steam-Chest Valve Body
2108 Steam-Chest Valve Cap
2109 Steam-Chest Valve Check
2233 Hand Oiler Packing Nut
2235 Hand Oiler Body
2236 Hand Oiler Stem
2237 Hand Oiler Filler Plug
2238 Water Check Stop
2239 11-16 Plugs
2240 Gauge-Glass Reflector
2241 Drain Valve Body
2246 Steam Valve-Stem
2247 Feed Valve Center Piece
2249 Tallow Pipe Center Piece
2251 Condenser Plug
2253 Steam Valve Center Piece
2254 Steam Valve Disk
2256 Filler Plug
2261 Feed Valve-Stem
2262 Support Arm
2264 Sight Feed Glass
2265 Feed Glass Packing Ring
2266 Rubber Packing
2267 Feed Glass Washer
2270 Oil Tube
2273 Feed Nozzle
2277 Oil Tube Bushing
2279 Air-Brake Check
2280 Check Seat
2284 Regulating Valve Handle
2285 Hand Oiler Handle
2286 Steam Valve Handle
2287 Filler Handle

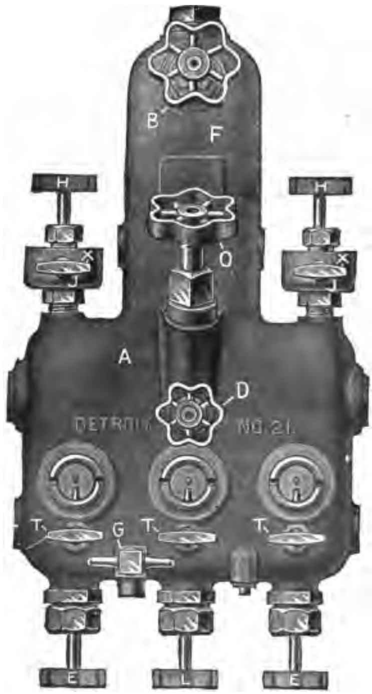


Plate 9, Fig. 1.

Construction. The Detroit No. 21 lubricator is a "Bull's Eye" pattern instrument. It differs from lubricators of the old type in that it has a sight feed glass which will not break under any condition of service, and all danger of injury to enginemen and delays resulting from the bursting of lubricator glasses have been removed.

The glass and its packing, as shown on Plate 9, Fig. 1, are so designed and located as to prevent sudden and extreme changes in temperature in the lubricator, thus reducing the expansion and contraction to a minimum.

The packing will neither vulcanize nor blow out. The metal formerly used in the arms, by-pass valves, etc., is now used in the metal line of the lubricator, its valve-stems and stuffing-boxes, giving additional strength and durability. The oil is maintained at a uniform temperature and will not chill. The feed is regular under all conditions and all feeds are visible from two sides of the lubricator.

An additional valve is placed on the top of the lubricator to control the supply of steam from the boiler, making the device self-regulating.

List of Operating Parts.

- F. Condenser
- A. Oil Reservoir
- O. Filler Plug
- G. Drain Valve
- TTT. Sight Feed Drain Stems
- D. Water Feed Plug
- B. Steam Valve
- EE. Feed Regulating Valves to Right and Left-Hand Cylinders
- L. Feed Regulating Valve to Air Pump
- WW. Couplings to Right and Left-Hand Cylinders
- R. Coupling to Air Pump
- C. Steam Connection
- JJ. Auxiliary Oilers

Operation. To fill the lubricator filler plug O, Plate 9, Fig. 1, should be removed and the reservoir filled with clean strained valve oil. If there is insufficient oil to fill the reservoir, add enough water to make up the required quantity. This will enable the feeds to start promptly. The boiler valve and steam valve B at the top of condenser F must be kept wide open while the locomotive is in service.

To start the lubricator it should first be ascertained

that the boiler valve is open, after which steam valve B at the top of condenser F should be opened and allowed to remain open while the lubricator is in operation.

Sufficient time should be allowed for the condenser and sight feed glasses to fill with water. Water-valve D

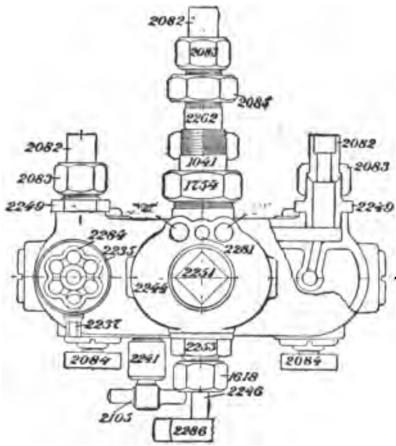


Plate 9, Fig. 2.

should be opened immediately after the steam valve is opened. The flow of oil to the cylinders should be regulated by valves EE and to the air-pump by valve L.

To operate the auxiliary oilers it should first be ascertained that valve H is closed. Valve X should then be opened and the cup of the oiler filled. Valve X should be closed after filling and valve H opened.

When refilling the lubricator, valves EE and L should always be closed before closing water-valve D. Drain plug G should be opened, and filling plug O removed.

The lubricator should be blown out at least once a week, or oftener when necessary.

In getting a new or a rebuilt locomotive ready for

service, the oil pipes should be disconnected at the steam-chest, and the oil pipes and automatic steam-chest valves blown out thoroughly. The coupling to the air-pump should also be disconnected and blown out and the choke plugs must have a clear opening. This operation should be repeated several times while the locomotive is being prepared for servicc.

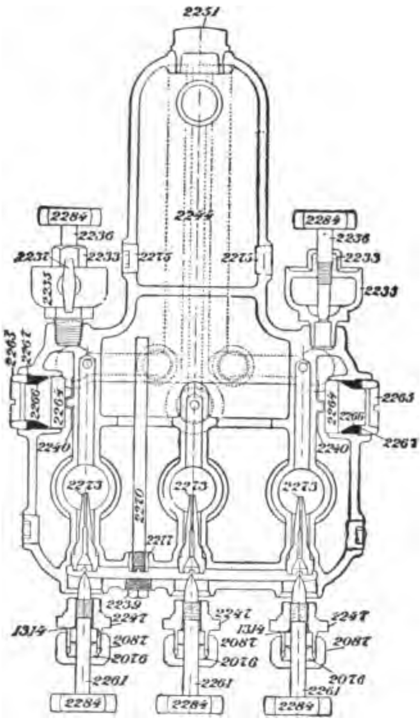


Plate 9, Fig. 3.

The feed giass follower (Fig. 41) should not be adjusted too tightly, as it would only serve to injure the packing. There is no danger of leakage at this

point, as the glass and packing are so designed that the greater the pressure from the inside the closer the joint.

Testing for Leaks. If the engineman has reason to

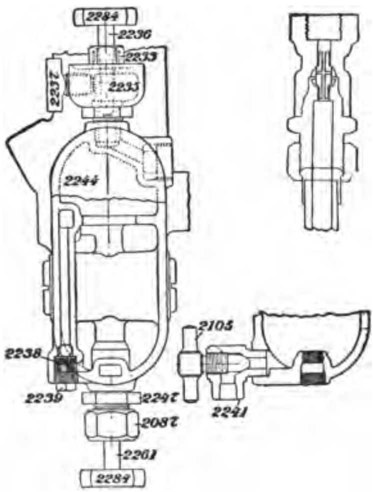


Plate 9, Fig. 4.

believe that the oil is escaping through a sand hole leading to either of the steam-chests or the air-pump, the defect can be determined by the following test:

The lubricator should be not less than two-thirds full of oil, and the full steam and water pressures used as in service. All vent stems, 2084 (Fig. 2, Plate 9), leading to the sight feed glass chamber should be opened and all water allowed to escape and steam allowed to blow through the vents for a period of one minute. Any two of the vents should then be closed and the scoop shovel, which should be clean, held under the jet of steam coming from the vent stem. If there is a sand hole through any one of the oil outlet passages, the jet of steam will carry the oil downward and deposit it on the

scoop. The same test should be repeated at the other vents. If no oil is deposited on the scoop, it indicates that there is no sand hole in the lubricator. Care should be taken that all oil is wiped off the feed regulating stems, nuts and center pieces before making these tests, or the steam would deposit this oil on the scoop, leading one to believe that it came from a sand hole.

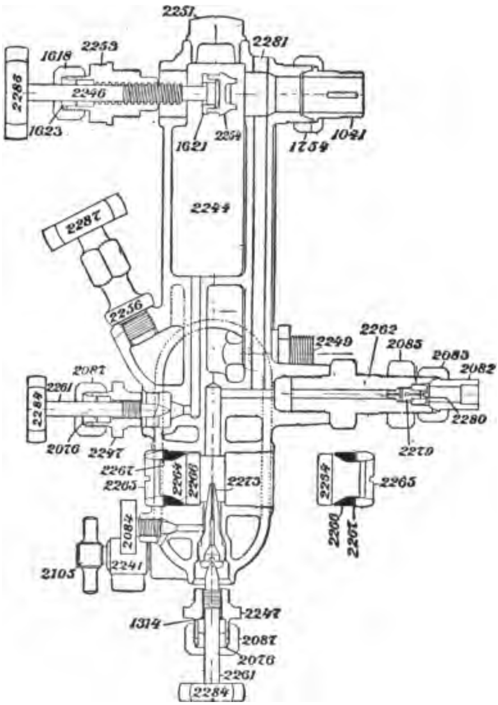


Plate 9, Fig. 5.

The above precaution should be taken if the feeds are closed, and the test commenced immediately, as there would be oil adhering to the passages and nuts above the

sight feed chamber, which would be drawn down in a reversed direction by the current of steam escaping to the atmosphere through the vents, and which should not be confounded with the oil that would escape from

Fig. 41.

a sand hole if there were one. A loose feed cone or a faulty seat would produce the same result. This test should not be made immediately after a lubricator has been filled with oil, especially if the oil is cold, as the expansion of the oil, if great enough, would force all of the water and probably some of the oil back through the water passages into the condenser, after which the oil would be drawn down through the equalizing tubes into the feed chamber, and would show all the indications of a sand hole.

Expansion of Oil. Oil taken at 60 degrees and heated to a temperature of 381 degrees will expand one-fifth in volume. It will thus be seen that it is of the greatest importance that immediately after the lubricator has been filled, the water-valve should be opened to permit the expansion to be relieved through the water-tube and condenser. If the water-valve is not opened the intense pressure caused by the expanding oil is sometimes

sufficient to destroy the body of the lubricator. Extreme pressure in the lubricator is indicated by a rush of oil from the feed cone the instant the feed stems are opened. The hotter the oil is before it is put into the lubricator, the less expansion will occur.

If the lubricator is hard to fill, without all pressures being shut off, the trouble is due to a leaky water-valve stem, which should be ground in, or exchanged for any of the feed stems (Fig. 2, Plate 9), which are all alike and interchangeable.

Siphoning. If the feeds race, or feed faster when the locomotive is shut off and is drifting or at rest, than when the throttle is open, by reason of the choke becoming enlarged, it is usually considered by many enginemen that the lubricator is siphoning. If, on account of a loose steam cone, sediment gathers around the base of the feed cone, or a piece of glass lies against the cone, or the oil feeds out through capillary action, it is erroneously called "siphoning." If the water-tube in the old style of lubricators and in some types of "Bull's Eye" lubricator became loose or cracked where it screwed in the condenser, or top of lubricator, and allowed the oil to transfer from the body of the lubricator to the condenser, it was also attributed to "siphoning."

It is a well-defined law of physics that in order to cause siphonage it is first necessary to create a vacuum. The Detroit lubricator will siphon out the oil only under the following conditions:

First: The lubricator must be full or partly filled with oil. Second: The steam valve on the boiler or top of the condenser must be closed and the water-valve to the lubricator open. Third: A vacuum must be created, and in order to create this vacuum the locomotive must be moved, the steam shut off and the locomotive allowed to drift. The cylinders are converted into air-pumps

while drifting, and as a result a vacuum is formed in the oil pipes and lubricator condenser. Conditions are then favorable for siphoning the oil out of the lubricator, provided the water-valve is open, and there is no check in the water-tube or water passage and no scale or sediment above the check which would prevent it from seating. If all of the conditions named existed at the same time, the oil could be siphoned out of the lubricator.

At times, enginemen open the water-valve before the steam valve, or close the steam valve before the water-valve, which is bad practice, as it places the lubricator in a favorable condition for siphoning out the oil if it is not protected by a check.

Caution. Steam valve B (Plate 9, Fig. 1) should always be opened first and water-valve D last when putting the lubricator to work. Water-valve D should be closed first and steam valve B last when shutting off the lubricator. If these instructions are followed the lubricator will never siphon, as a vacuum cannot be created in the condenser and oil pipes when steam pressure is admitted to the lubricator.

HINTS ON THE CARE OF LUBRICATORS.

All lubricators will give better results if cared for intelligently than if neglected.

If no precautions are taken to prevent it, the water passages will close up with sediment between the condenser and the oil reservoir as completely as if the water-valves were closed.

All lubricators should be blown out at least once a week, and oftener in districts where the water is bad.

The reservoir and the glasses may be kept clean by putting a piece of soap in the reservoir about once a week.

Valve oil and engine oil should never be mixed and used lubricator, as the temperature of the lubricator is too

high for engine oil, and would cause it to carbonize, destroying the lubricating properties of the oil. Particles of carbonized engine oil have no greater lubricating properties than powdered charcoal.

If the supply of valve oil is not sufficient to last until a terminal point is reached at the regular rate of feed, the feed should be decreased. The valves should not be wet and the engine should be run with a lighter throttle and a longer cut-off, and should not be allowed to drift without the throttle being slightly opened.

The chokes at the steam-chest are constantly being cut away by the action of the steam, and should be renewed when sufficiently worn to affect the regularity of the feed. The chokes also act as a balance for the equalizing of pressures.

The steam valve on the boiler and the one on top of the condenser must be opened wide in order to counteract the steam-chest pressures.

The quantity of oil consumed per mile increases as the speed of the train decreases, and it correspondingly decreases as the speed increases.

Salt water is more buoyant than fresh water, and for this reason will force the drop of oil off the feed cone sooner. There would be more drops of oil per minute than if the water in the sight feed chamber were fresh, but the quantity of oil would not be any less. When water in the sight feed chamber becomes salty it is carried into the chamber from the boiler by the mechanical action of the steam.

A constant evaporation is taking place in the condenser of all types of locomotive lubricators. The same condition also exists in the outlet of the sight feed chamber.

There are two principles involved in a locomotive lubricator. The first is hydrostatic. The hydrostatic pressure ends on the point of the feed cone. From that point to the surface of the water in the sight feed chamber, the oil

travels at the rate of 30 feet per minute. The second is that the oil coming in contact with the steam is carried to the steam-chest by gravity, heat and motion.

Chokes located at the steam-chest give more satisfactory results than those located at the lubricator, as the boiler pressure passes down to the steam-chest chokes and prevents back pressure into the oil pipe and also permits the lubricator to feed against a constant boiler pressure, instead of feeding against a fluctuating oil pipe pressure, when the chokes are located at the lubricator. All oil used in the lubricator should be carefully strained, as it will not feed oil filled with foreign matter or coarse solid substances.

If there is insufficient valve oil to fill the lubricator, enough water should be added for the purpose. This will enable the feeds to be started promptly.

If at any time it becomes necessary to fill the lubricator with cold oil, and the engine is to remain out of service for several hours, the steam pressure should be turned on slightly at the boiler, and the water-valve D should be opened in order to prevent excessive pressure from the expansion of the oil.

The steam valve controlling the pressure from the boiler to the condenser should be opened wide when a locomotive is in service, to allow ample condensation to take place in the condenser. With the steam valve only partially open, the small volume of steam will be diverted into the equalizing tubes. The feeds will gradually slow down as condensation decreases.

On engines which use soda-ash boiler compounds, or which run in bad water districts, lubricators will carry impurities into the condenser, and will gradually accumulate them at the base of the water-valve (unless they are frequently blown out) until the water is completely shut off. At times these impurities lodge above the water check. While the water-valve is becoming clogged the feeds will

be affected, by reason of insufficient water entering the lubricator, and finally the passage will be closed by the sediment and the feeds will cease to work.

When the feeds close while the locomotive is in service, all feeds and the water-valve should be closed, the drain cock opened and about one-half pint of water allowed to drain off. The drain cock should then be closed and the water-valve opened quickly. The condenser pressure will force the sediment to the bottom of the lubricator, where it can be blown out in the usual manner when the lubricator is empty.

If the lubricator siphons, the trouble should be looked for at the water check. It may be caused by scale or borings preventing the ball check from seating, or the check may have been lost by removing plug 2239 (Fig. 3, Plate 9).

The follower on a sight feed glass should not be adjusted too tightly, as it will only serve to injure the packing. There is no danger of leakage at this point, as the glass and packing are so designed that the greater the pressure from the inside the better will be the joint.

The cause of small drops of oil or a variation of the size of drops is that the water supply has become impregnated with saline matter. This occurs in alkali, salt water or oil well regions from which the water supply is obtained. The saline matter is carried to the lubricator mechanically by the steam, so that the water in the sight feed glass contains a considerable quantity of it, and the amount increases until it crystallizes around the feed cones, thus gradually diminishing the size of the opening from which the oil enters the feed glass.

This difficulty can be remedied by closing all feed stems, opening all sight feed drain stems and blowing them out thoroughly, the action of the steam dissolving the salt crystals on the cones. Sufficient time should be allowed for

condensation, after which the feeds should be started, and the drops will be of normal size.

When a lubricator becomes air-bound it is brought about by filling the lubricator while on the road. The temperature in the oil reservoir being nearly that of the steam pressure, the oil will expand readily. The filler plug is usually put in before the reservoir is filled. The steam and water pressures are hurriedly turned on and the feeds are also turned on before sufficient time has elapsed for condensation to accumulate enough water to fill the reservoir completely. The feeds will not respond under such conditions, for the reason that the positive pressures having equalized, the lubricator has become air-bound.

This trouble can be overcome by opening all feeds and one of the sight feed drain stems, which allows the water in the oil tubes and the air or gas occupying the highest space in the oil reservoir to escape to the atmosphere. The oil will quickly follow. The open feeds and vent stem should then be closed, until the condensation again fills the sight feed chamber.

When irregular feeding or racing occurs the trouble should be looked for at the automatic steam-chest valves, or at the chokes located at the lubricator end of the oil pipes. When the opening through any of these chokes has become enlarged above the standard, the feed will race when the engine throttle is closed.

The cause of the lubricator racing is due to the fact that the steam pressure is not maintained on the water in the sight feed glass on account of the suction from the cylinder, which allows the oil to feed faster when the throttle is closed than when open.

The difference between a clogged equalizing tube and a clogged choke tube is that if the choke is stopped up the glass and the equalizing tube will fill up with oil when the throttle is open, but when the throttle is closed and the

equalizing tube is stopped up, the oil disappears from the glass, which does not occur when the choke is stopped up.

To operate the lubricator when the steam-pipe leading to the condenser is broken, a blind gasket should be put in at the pipe connection at the condenser and the feed to the air-pump opened, which will allow the steam to back up through the sight feed and into the condensing chamber, and the lubricator can then be operated. If the air-pump pipe does not furnish enough steam through the choke, the choke plug in the pipe leading to the pump should be taken out and the pump lubricated by removing the caps on the pump head at frequent intervals.

When a high pressure is used there is a tendency for a gummy substance to collect around the feed stems and cones. This substance can be removed and the glasses cleaned and filled in the following manner:

After all the oil is fed from the lubricator, the pressure should be left turned on and all feeds closed except one. The vent stem to this feed should then be opened, which will allow the condensation to circulate and thoroughly cleanse the feed stem, cone and glass. The vent stem should be closed and the glass will immediately fill with condensation from the lubricator. The feed stem should then be closed. The same operation should be repeated with the other feeds. The water feed valves should then be closed, the body of the lubricator blown out and the lubricator then filled with oil in the usual manner.

PISTON AND VALVE-STEM PACKING.

UNITED STATES METALIC PISTON AND VALVE-STEM PACKING.

Fig. 42 shows a sectional view of the piston rod packing.

Fig. 42.

List of Parts.

2. Babbitt Metal Ring
3. Follower
4. Ball Joint
5. Swab Cup
6. Vibrating Cup
7. Gland
8. Preventer

Fig. 43 shows sectional view of valve-stem packing.

List of Parts.

2. Babbitt Metal Ring
3. Follower
4. Ball Joint
5. Swab Cup
6. Vibrating Cup
7. Gland
8. Preventer
9. Support

Fig. 43.

Construction and Operation. The principle of operation is as follows: The babbitt metal rings which serve to make the joint around the piston are the only parts which come in contact with the rod. These rings are contained in the vibrating cup, and are forced into the cup against the rod, which causes them to close as they become worn by steam pressure. The purpose of the spring is to hold the

rings and other parts in place when steam is shut off. A ground joint is made between the flat face of the vibrating cup and the ball joint. There is also a ground joint between the ball joint and the gland. The combination of the sliding face of the vibrating cup and the ball joint permits the packing to fit around the rod closely, without any increase in friction. Should the piston be out of line by reason of wear occurring between piston head and cylinder, it will cause more or less vibration of the piston rod, and if not protected by the sliding face of the vibrating cup and ball joint, the piston would ruin the packing in a short time.

Follower and Preventer. The flanged follower and preventer are used to prevent the babbitt metal rings and parts from getting sufficient clearance to allow the steam pressure to seat them with sufficient force to damage the rings.

Gland. The parts of the packing are held in place by the gland which is bolted to the face of the stuffing-box, a copper gasket being used to make a steam-tight joint.

Swab Cups. A swab cup is fastened to the outside of the gland, which is filled with swab material, and is kept saturated with oil. This not only serves to assist in lubrication, but also prevents dirt, dust and other foreign matter from being carried into the packing and destroying the rings.

Vibrating Cups. The vibrating cup 6 is shown in Figs. 42 and 43. The combination of the acute and obtuse angle allows the rings to feed into the cups and against the rod as the wear takes place, and at the same time prevents them from being forced out along the rod through the space between the rod and the opening of the cup.

Metal Rings. A set of metallic packing consists of three rings which are cast with a flanged opening, the flanges overlapping each other when in service, making a

steam-tight joint, with a small open space left between the flanges so that they will quickly adjust themselves to the surface of the rod. When the rings have become adjusted, their ends will come solidly together. When in this condition, the packing will wear longer than if the rings were continually cut so that the ends would stand apart. Rings should not be cut open after being applied, as the wear on them will be excessive, and they will have a tendency to force out between the vibrating cup and the rod.

AURORA L. & K. METALLIC PISTON AND VALVE-STEM PACKING.

Fig. 44 shows a sectional view of the piston rod packing.

List of Parts.

B. Stuffing Box Bushing
C. Tee Ring
D. Outside Gland
F. Packing Rings
G. Split Cast-Iron Re-enforcing Rings
H. Retaining Springs

Construction and Operation. The gland used with the L. & K. packing (Fig. 44) is made entirely of cast-iron and consists of five parts, as follows: B, Stuffing-Box Bushing; C, Tee Ring, which forms the grooves; D, Outside Gland, which may have the swabholder cast on it if desired; G, two Split Cast-Iron Re-enforcing Rings, held together by steel Retaining Springs H. Parts B, C, and D are bored one-half inch larger in diameter than the full size of piston rod, which allows them to pass over any enlarged crosshead fitted to that size. The re-enforcing rings G have nothing to do with making a steam-tight joint. Their only office, as their name implies, is to prevent the steam pressure from forcing the soft packing rings through the opening between the piston rod and the bore of parts

C and D. Accordingly, the re-enforcing rings are bored one thirty-second inch larger than the rod to prevent scoring it.

The grooves for holding the metallic packing and

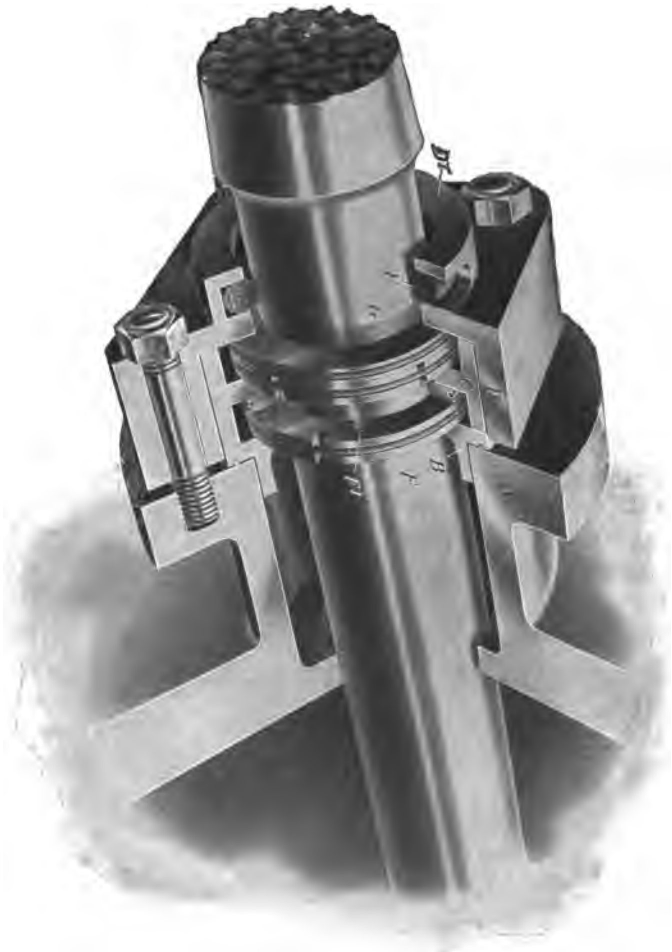


Fig. 44.

re-enforcing rings are formed by the Tee Ring C, the outside face of B and the inside face of D. These faces are smooth-finished, making steam-tight joints when the gland is in position.

To allow packing rings to follow any vibratory motion of the piston rod, due to faulty alignment or wear of the crosshead, the diameter of the grooves is five-eighths of an inch and the width one thirty-second of an inch larger than the corresponding dimensions of the packing rings.

Valve-Stem Packing. Fig. 45 shows a sectional view of the valve-stem packing.

List of Parts.

B. Stuffing-Box Bushing
C. Tee Ring
D. Outside Gland
F. Packing Rings

By comparing Figs. 44 and 45, it will be noted that the locomotive valve-stem and piston packing do not differ in any material respect.

When applied to a slide-valve, the stuffing-box bushing B is made of bronze and supports the weight of the stem and yoke, at the same time acting as a guide for the rod.

For piston valves, the bushing B is made of cast-iron.

For valve-stems, the re-enforcing rings are not necessary, as there is no enlargement of the rod, and accordingly the parts B, C and D are bored only one-eighth inch larger than the valve-stem.

Packing Rings. The packing rings F are made of white metal of special composition, and are generally two in number, consisting of four segmental pieces, each having broken joints arranged in such a manner that they form steam-tight rings when under pressure.

Each segment has a feeding tongue, F-1, which wears off as the packing closes up on the rod.

Fig. 45.

The four segments F, forming a ring, are held in position by the retaining spring H, which, however, does not aid in making a steam-tight joint on the rod.

General Information. Unlike most forms of packing, no heavy coil spring is used to secure a steam-tight joint between the packing rings and the piston.

This packing depends entirely upon the steam pressure to make tight joints, and for this reason there is practically no friction on the rod when the engine is not working steam.

When under steam pressure, the rings are forced tightly against the outer wall of their respective grooves, and the steam also presses the segments tightly upon the rod, thereby forming a steam-tight joint.

In service, the segments close up along a plane parallel to the circumference of the rod, and hence the packing remains steam-tight until the segments have closed up entirely, due to wear. After this has occurred, the packing rings should be renewed.

LUBRICATION.

Oiling the Engine. The lubricator and the rod cups should first be filled, after which, if possible, the engine should be placed in such a position that all parts can be oiled without moving the engine a second time in order to reach driving boxes, valve gears and wedges. If the driving box is made as shown in Fig. 46, a small quantity of oil should be put in the oil pocket which leads to the wedge, and a sufficient amount should be put in the center pocket. Care should be exercised in putting the oil intended for

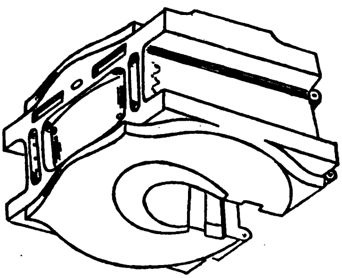


Fig. 46.

lubricating the journal well over toward the inside of the driving box, as the cinders and dirt accumulate around the axle on the inside of the box, there being nothing to hold the oil or protect the box from dirt. The inside usually becomes dry first, the heating of the box starting at that point. The shoe and oil pockets on the front side of the box should be treated in the same manner as the wedge.

The quantity of oil used during the first oiling should be liberal, as at other points where oiling can be done the time may be limited, and if the engine be thoroughly lubricated before leaving the terminal, it will be necessary to use but a small amount of oil during the balance of the

trip. After the first box is thoroughly lubricated, the second box should be treated in the same manner. The eccentrics, links, hangers, rocker boxes, shafts and all other connections to the valve gear should then be oiled. Next, the guide cups should be filled and the feeds set. The guide cups should not be filled too full, as the oil will run over the side of the cups and be wasted.

The piston and valve-stem swab should then be oiled or the swab oil cups filled, if cups are provided. The engine trucks should then be oiled, after which the other side of the engine should be oiled in same manner.

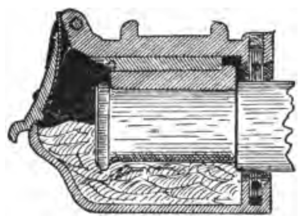


Fig. 47.

The boxes of the tender trucks should then be examined, to see if there is sufficient packing. If the packing appears dry it should be oiled and the waste placed well up under the journal (Fig. 47).

Disturbing Packing on Top of Driving or Truck Boxes. It is bad practice to disturb the packing on top of driving and engine truck boxes with the spout of the oil can when oiling the engine, for the reason that it stirs up any dirt, cinders or sand which may have lodged in the packing, and they are liable to work down with the oil to the bearings. The disturbing of the packing also destroys the fine feed channels which have formed in it, causing the oil to take another course, and may cause the bearing to become heated.

Rod Grease Cups. Grease cups should be filled to within one-half inch of the top. Care should be taken when screwing down the plug not to force too much grease on the pin. A good practice is first to try the rod on the pin; if it moves freely, the plug should be screwed down until the rod is hard to move, which will indicate that the pin has been given sufficient grease. Having had a little experience, an engineman can tell just about how much of a turn should be given the plug to insure safe running of the pin without heating.

It is common for pins to run warm while using grease, for the reason that the grease must be melted into the form of oil in order to lubricate freely. There is no danger of the pin becoming overheated when given room in the brass and a reasonable amount of grease.

Too much pressure on the grease plug will cause the grease to be wasted and the friction will be increased.

Oil should not be used with grease, as the oil would cause the grease to soften and work out, leaving the bearings without lubrication.

Hard Grease in Driving Cellars. On an engine equipped with grease in the driving box cellar, the engineman can ascertain whether there is enough grease in the cellar to make the trip by the indicators which are fastened to the follower on the bottom of the cellar.

If the cellar requires packing on the road, this can be done by removing the plate on the side of the cellar, pulling down the indicators, which compress the spring, and then refilling the cellar with grease. Care should be taken to get the grease between the perforated plate and the plate on top of the spring. If there is insufficient rod grease for the purpose, enough grease should be taken from the other driving boxes, or a certain amount of grease can be put in, and a quantity of hard soap placed on top of it.

Engine Oil Not to Be Used on Valves or in Steam

Cylinders. Engine oil should not be used on valves or in steam cylinders for the reason that it will evaporate and become like a gas which has no lubricating properties, when subjected to as high a temperature as that of steam.

STARTING THE LUBRICATOR.

Valves, cylinders and air-pumps are lubricated by means of sight feed lubricators and force-feed.

The feed valves on the lubricator should be opened and allowed to feed slowly, at least thirty minutes before an engine leaves its terminal.

The proper rate of feed is from five to ten drops per minute for cylinders (depending on the service) and one drop per minute for the air-pump.

It is bad practice to carry water too high in the boiler, as the water is carried over the throttle and through the dry pipe to the steam-chest and washes the oil off the valves and cylinder walls, thereby causing them to cut, and is liable to cause damage to the cylinder head.

If a valve appears dry when steam is being used and the lubricator is working, the engineman should ease off on the throttle, and drop the lever down a few notches.

INSPECTION OF BEARINGS.

To insure successful lubrication the engineman must examine all bearings to see that they are properly packed, see that all oil holes are open and that the waste in the cellars is up against the journal, feel all bearings to ascertain whether they are running hot, and, if found to be heating, give them necessary attention and lubrication.

The feeders of oil cups should be adjusted according to the requirements of the bearings, and should always be closed at terminals.

It is bad practice to keep engine oil close to the boiler in

warm weather, as it will become too hot and run off the bearing too readily when applied.

TREATMENT OF HOT BEARINGS.

Engine Trucks. A bearing which becomes hot should always receive prompt attention. If an engine truck is running hot the brass and cellar should be examined and the cellar packed if necessary. If equipped with a water line the water should be turned on for cooling purposes. If without a water line, the engineman should see that the journal is getting oil. If the brass is defective it should be replaced.

Driving Boxes. If a driving box is running hot, the oil holes should be examined to see if they are open, and the cellar examined to see if it is well packed. If the packing is not up against the journal it should be repacked. If the engine is equipped with a water line, the water should be turned on for cooling purposes, and the wedge pulled down enough to prevent sticking. If the box continues to run hot, it should be relieved of a part of its weight, by running the driver on a wedge and placing a block between the saddle and frame or between the equalizer and frame.

Guides. If the guides run hot, they should be cooled off with oil, and care should be exercised to see that they get sufficient lubrication. If a crosshead works too tightly in its guides, causing them to heat, they should be shimmed up by placing liners at both ends, if necessary.

Rods. When the forward end of the connecting rod runs hot, the engineman should see that it is getting proper lubrication and that the oil is feeding freely. If it is keyed too tightly, he should slack up on the key, and if too loosely, which would cause heating, it should be keyed up. If the back end of a connecting rod is running hot and has started the babbitt, he should keep going until all of the babbitt

has been thrown out of the brass, and then come to a stop. The key should be slacked up, the pin cooled off, and if the feed is stopped up, it should be taken out and cleaned, and the cup refilled with either grease or good oil. The heating of the back end of the main or connecting rod can do no further harm to the engine, when given room on the pin and a sufficient supply of lubrication.

If a side rod runs hot it should be treated in the same manner as a connecting rod. If the main wedge is down it should be set up, as this is the usual cause of side rods running hot.

Eccentrics. If an eccentric runs hot, it should be given a sufficient supply of oil, and examined to see if the eccentric cam bolts are loosening up. If so, they should be tightened, as their loosening will cause the eccentric to bind in the strap. If the trouble is due to the eccentric strap being too tight, shims or liners should be inserted at the top and bottom of the strap. Water should never be used on a hot eccentric; oil only should be used.

Trailer or Tender Truck. If a trailer or tender truck runs hot, it should be repacked; if a water line is available it should be turned on, the brass examined, and if found defective, it should be replaced.

Use of Valve Oil. Valve oil or grease should be used on hot bearings which are too hot to be cooled by ordinary car or engine oil.

FRICTION.

The rubbing together of any two surfaces constitutes friction and produces heat. The interposing of a thin layer or coating of lubricant, so that the two surfaces do not actually come in contact with each other, lessens the friction.

The amount of friction produced is determined by the resistance between the two bodies in contact, which opposes the sliding of one upon the other, the pressure of one body

bearing upon the other, the nature of the material or materials in contact or the nature and lubricating properties of the interposing lubricant. Speed and temperatures are also determining factors.

WATER SUPPLY.

When leaving a terminal or starting from a station or siding there should be sufficient water in the boiler to get the train under headway before using the injector. Water should then be supplied to the boiler in quantity equal to that consumed by evaporation, the supply to be increased or decreased as the nature of the work demands. The water supplied to the boiler should not exceed the consumption by evaporation, as increasing the supply when the engine is working steam tends to destroy the steaming efficiency of the majority of engines. On way freight or other trains which are required to make indefinite stops at stations, the supply of water in the boiler should be allowed to decrease slightly between stops, which aids in the maintenance of pressure and results in a more economical use of fuel, the supply being replenished at stations during the stop or while the work is being done. This aids the fireman in keeping the fire bright, and supplying water at frequent intervals prevents the engine from blowing off. On switch engines water should be supplied to the boiler at times when there is the least drain on it. Engines pulling cinder pit tracks or putting coal on docks should be given a good supply of water in order to protect the crown-sheet. When leaving the engine at the cinder pit a good fire should be left burning, and at least two gauges of water in the boiler, which will eliminate the necessity of working the injector during the time that the fire is being cleaned and supplies taken.

PRIMING AND FOAMING.

Priming and foaming are terms commonly used when the water is carried from the boiler, through the throttle and dry pipe, to the cylinders. Priming is usually caused by an oversupply of water in the boiler, due to negligence on the part of the engine-man or other employe in charge of the engine. At times priming is due to the difference in the temperature and pressure in the water below the steam. When the throttle is opened suddenly the pressure on top of the water is relieved, which will create a rapid generation of steam, and cause rapid circulation in the boiler, filling the space from which the steam has been drawn. As soon as the pressure is relieved through the throttle, bubbles of steam will flow from the heating surface of the boiler to the point at which the steam is escaping through the throttle. The rapidity of these bubbles would be so great when passing to the dome that large quantities of water would be carried with them.

The foaming of the boiler is usually caused by some foreign substance in the water, such as oil, soap, grease or alkali in districts where the feed water is bad. One of the causes for water being carried into the throttle and foaming is due to a measure of the steam passing over the surface of the water to the outlet or throttle, carrying particles of water with it. If the engine is allowed to blow off during the time the boiler is foaming it will increase the flow of water toward the dome. When the safety-valve is open the pressure in the boiler should be reduced, which will assist in preventing the water from being carried into the dome.

In addition to foreign or oily matter causing the boiler to foam, the use of foul or dirty water is one of the prime causes of foaming. Frequent washing of the boiler will eliminate this troublesome feature to a great extent.

In bad water districts it is necessary to change the water or wash the boiler each trip. When an engine is priming or foaming it can immediately be detected by the engineman, the exhaust having a muffled or dead sound, in addition to showing a white vapor at the stack. In addition to this, the water in the water-glass will rise, indicating a full glass of water. When these indications appear, the cylinder cocks should be opened at once to prevent water accumulating in the cylinder and the consequent danger of the cylinder head or piston being broken. The throttle should be partially closed, dropping down the lever and working the engine at a longer stroke, if necessary, to handle the train.

In the event the water does not settle to its level, the throttle should be shut off momentarily, and the water will seek its level and indicate the correct amount of water in the boiler. Some types of engines are equipped with a surface cock located in the back end of the boiler, between the upper and lower gauge-cocks. With the use of the surface cock, foul particles which have risen to the top of the water can usually be blown out.

Should the priming or foaming continue during a trip, the boiler should be thoroughly blown out at frequent intervals in the manner previously described, which will assist the engineman in reaching the terminal without causing an engine failure.

During the time the boiler is foaming there is danger of exposing the crown-sheet to the fire and consequent liability of its becoming overheated. There is also danger of knocking out a cylinder head. Both priming and foaming will cause the lubrication to be washed off the valves, causing them to cut, unless given extra lubrication, and will frequently cause the cylinder packing to break.

Valves and cylinders should always be kept free from water to prevent all chance of rupture, which would neces-

sarily occur if water passed to the cylinder and the piston were forced to the end of its stroke.

WEDGES.

Fig. 48 shows the wedge, wedge bolt and shoe as attached to the frame. When setting up the wedges, the engine should be placed on a straight level track under steam, this being necessary for the reason that the parts of the frame which lie against the fire-box expand when heated and become longer than when the boiler is cold.

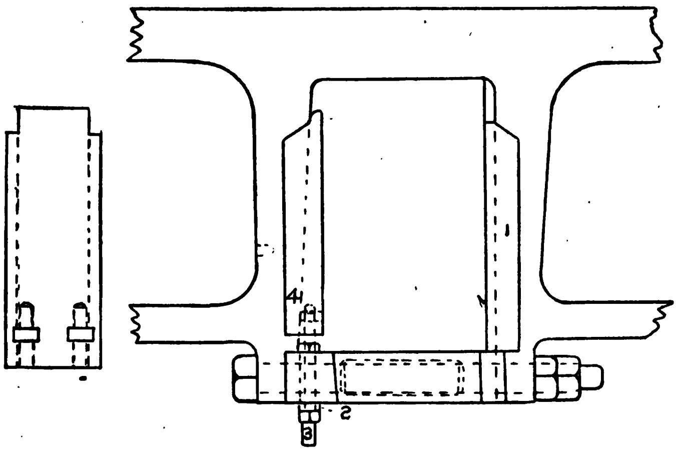


Fig. 48.

When setting up a wedge, the engine should be placed on the top quarter and a block then placed on the rail back of the wheel on which the wedge is to be set up. The engine should then be moved back against the block. The placing of a block back of the wheel is to move the driving box solidly against the shoe, so that all lost motion between the jaw and the box will be taken up back of the box, thus

permitting the wedge to be readily set up. If the wedges are to be set up all around, the engine should be placed on the top forward eighth on the right side. This will place the engine on the top back eighth on the left side. The engine truck wheels should then be blocked ahead, the reverse lever placed in the forward motion and the throttle opened. This will admit steam back of both pistons, and pull all the driving boxes up against the dead wedge or shoe 1, so that all the wedges can be set up without again moving the engine. The jam nut 2 and then the wedge bolt 3 should be loosened, after which wedge 4 should be pried up with a small bar. On an eight-wheel engine the wedge on the main driving wheels should be set up snugly, and then pulled down about one-sixteenth inch, or until the wedge is free between the box and jaw, and the other driving wedges should be pulled down about one-eighth inch, which will insure a free movement of the boxes. On ten-wheel engines the front and back wedges should be pulled down about one-eighth inch and the main wedge about one-sixteenth inch. Wedge bolts (3) should then be adjusted in such a manner as to keep wedges 4 in their respective positions and jam nut 2 tightened.

A broken wedge bolt frequently causes the wedge to stick to the box, pulling it up solid between the box and jaw, causing the driving box to run hot.

When, with heavy engines or engines with solid side rods, it becomes necessary to set up a wedge with the wedge bolt broken, it can be done by placing a nut on the top and bottom of the wedge, and securing them in position with a wire. Care should be taken to prevent the wedge from being set up too tightly.

If the wedges are set up too tightly, and the driving box sticks, the engine will ride hard, having an up and down motion, and will cause driving boxes to run hot. With wedge stuck solid, to pull the wedges down, the jam nut

should be loosened and the wedge bolt tightened up to pull the wedge down, or the wedge pried down. A wedge can also be brought down by running that wheel over a nut placed on the rail, with wedge bolt tight.

If, when a wedge is up against the lower part of the top frame, and there is still lost motion between the wedge and the driving box, it should be reported lined down.

ROD BRASSES.

Rod brasses should be reported for filing when there is sufficient lost motion to cause a pound, or the brasses are keyed brass to brass, or so closely together that the edges of the brasses meet, and if the pounding continues should be reported for lining up when the key is down to a point where it cannot be forced further, in order to prevent the brasses from working in the strap.

Keying Main Rod Brasses. When it is necessary to key up the forward end of the main rod brasses, the engine should be placed on the top or bottom quarter, and at the top forward eighth or the lower back eighth to key up the back end of the rod. With the engine in these positions the rod is bearing on the largest part of the pins, and when free at these points will also be free at all other points and will not bind or heat. The crank pins are perfectly cylindrical when put in the wheel, but as the greatest wear takes place when the steam pressure is the highest in the cylinder they wear unevenly.

Steam is first admitted to the cylinder when the piston is at or near the beginning of the stroke. This causes the greatest wear to take place on both sides of the pin when the engine is passing the center. The average cut-off for all classes of service is considered half stroke. The steam line will be cut off when the crank pin is at or near the quarter of each stroke. Therefore, when an engine is in the

forward motion, the wear on the crank pin and wrist pin will take place while the pin moves from the forward center to the lower quarter, and from the back center to the top quarter, and the brass will open and close with each stroke, unless properly keyed.

The valve has reached its greatest opening when the crank pin is at or near a point midway between the forward center and the bottom quarter. The pin must, therefore, be smallest between these two points. The main rod brass should always be keyed on the largest part of the pin, and the engine should be placed to bring the pin opposite the two points mentioned.

The brass should be keyed moderately tight and then moved sideways at both front and back ends, after which the set-screws should be tightened.

For keying up the back end of the main rod, the top forward eighth is preferable, for the reason that in keying the brass to the pin it can be done without shifting the weight of the rod. When keying up the forward end the bottom quarter is preferable, as the brass can be keyed to the pin without shifting the weight of the rod, and it is also easier to get at the set-screws on a double guide engine.

Keying Side Rod Brasses. When the side rods are to be keyed up, the engine should be placed on a straight and level piece of track and on the center on the side which is to be keyed. The wedges should be set up, and all keys on that side slacked off. The main connection should be keyed first. To key the side rods the proper length, with the double keyway in the middle connection and solid end rods, one of the keys should be driven out and the other one driven down as far as it will go, marked and then driven out. The other key should then be driven down and marked in the same manner, and then driven up part way. Both keys should next be

driven down an equal distance, which can be determined by the marks, and then keyed down so that the rod can be moved laterally on the pin.

If the side rods are equipped with one key on the forward and back end and two keys in the middle connection, the forward and back ends should be keyed first and the difference divided on the middle connection keyway. If the side rod is provided with a single keyway in the forward end, single in the middle and a double keyway in the back, the middle should be keyed first, the front next, and the difference divided on the double keyway.

After the rods have been keyed on the center, the rods should be tried on the center opposite to the one on which they were keyed, care being taken to see that they move laterally and do not clamp the pin. It is also well to try the rods on the quarter, as old pins may have been worn out of round. The rods on the opposite side of the engine should then be keyed in the same manner. A sufficient amount of play should be left in the rods, especially if the driving boxes are badly worn. If there is no allowance made for lost motion in the driving boxes and wedges, the side rods will be subjected to severe strain and liability of breaking the pins, in addition to causing excessive wear and running hot.

The engine should always be placed on the dead-center when keying up side rods. If they are keyed in any other position there is a possibility of keying the rods either too long or too short, or out of tram, so that they cannot pass the center without binding or heating. An engine is out of tram when the driving wheel centers and pin centers are not the same on both sides of the engine.

Brasses should be properly keyed up at all times. A failure to do so will cause a constant pounding of the

rods, which will cause the brasses to heat and break. They will also loosen rod cups and strap bolts, pound all nuts and bolts about the engine loose, causing unnecessary wear to the rod brasses, in addition to causing a loss of power.

VALVE MOTION.

Controlling and Operating Parts. The parts which control and operate the valve motion, as shown in Fig. 49, are as follows:

1. Reverse Lever
2. Reach Rod
3. Reversing Arm
4. Tumbling Shaft
5. Lifting Arm
6. Link Hanger
7. Link Saddle
8. Pin
9. Link
10. Eccentric
11. Strap
12. Blade
13. Link Block
14. Link Block Pin
15. Top and Bottom Rocker Arm
16. Valve Rod
17. Valve-Stem
18. Yoke
19. Valve

Tracing the Steam from the Boiler to the Atmosphere. Fig. 50 shows an interior view of the boiler, throttle, stand pipe, dry pipe, and steam pipe and also the manner in which they are connected. When the throttle is open, steam passes by throttle valve A in the dome, through stand pipe B, to dry pipe C, through the dry pipe to the nigger-head D in the smoke arch and thence through the steam pipes E to the steam passage F in the cylinder saddle and to steam-chest G. When the port is uncovered by valve H for the admission of steam to the cylinder, the piston is forced to the opposite end, thus transmitting its power to the crosshead and main rod, thence to the pin, wheel and rail, and from the journal and eccentric to the valve motion, giving the forward and backward motion to the valve, shutting off the admission of steam to the cylinder and opening the exhaust port J just before the piston has completed its stroke. The steam then passes out through the same

steam port H through which it entered, either by the end of the inside admission piston valve, or through the

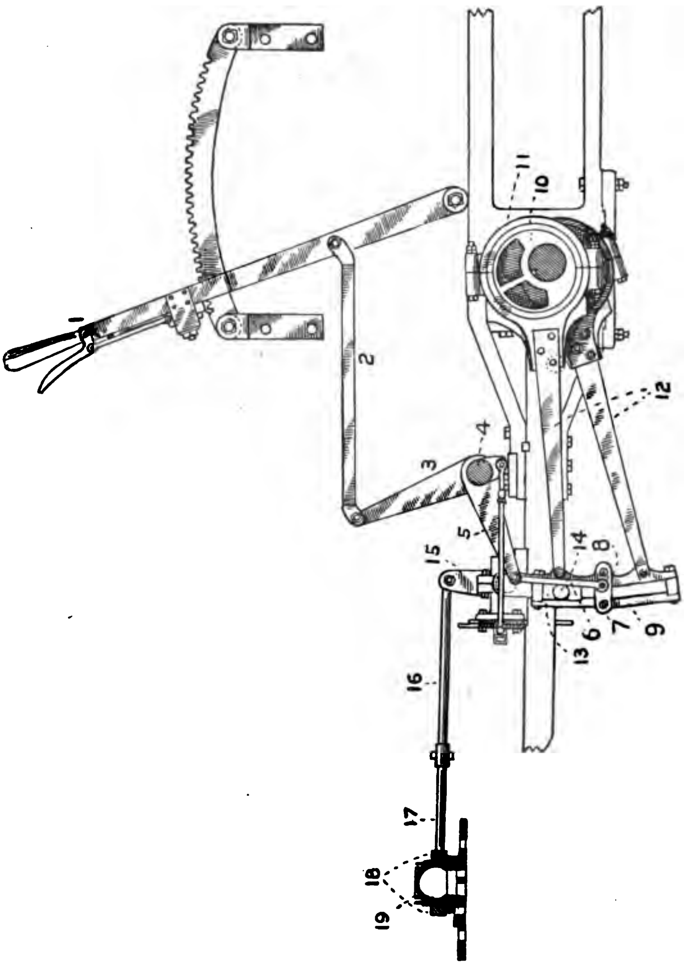


Fig. 49.

exhaust cavity I to the exhaust passage J, through exhaust stand K and nozzle L, through petticoat-pipe M,

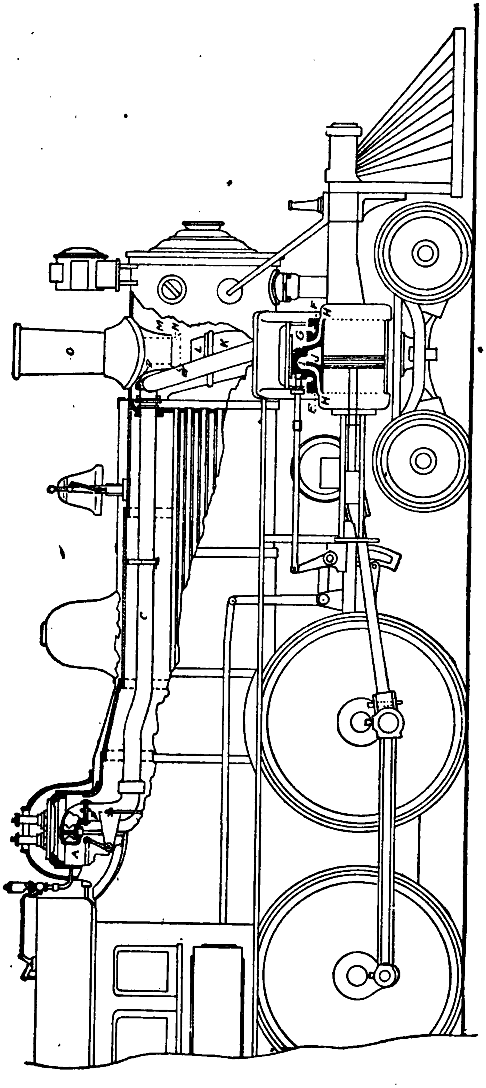


Fig. 50.

and sleeve N, if used, to the stack O and out to the atmosphere.

Steam Admission. Steam is admitted to the steam-chest through two channels AA (Fig. 51), called steam passages, which are cast in the cylinder. These passages terminate in a smooth flat surface BB called the valve-seat. The openings CC are the steam ports. Between them is another cavity D, called the exhaust cavity, and the exhaust arch E is directly over the exhaust cavity D. The shape of these ports is long and narrow, shown in Fig. 51. Over these ports is valve V, which is usually made of cast-iron, and so constructed that by moving it

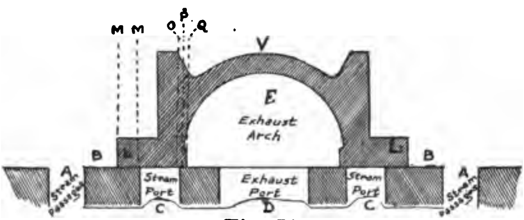


Fig. 51.

forward and backward its movement will alternately cover and uncover the steam ports CC. The valve and seat are inclosed in the steam-chest (Fig. 55), to which steam is admitted from the boiler through the dry pipe.

Steam Exhaust. The locomotive exhausts steam four times during one revolution of the driving wheels. When the right-hand crosshead has moved back from forward center to nearly the middle of the guides, the left engine is exhausting on its forward stroke. When the right-hand crosshead reaches a point close to the back end of the guides, the right engine is exhausting on the backward stroke. When the crosshead on its return movement nearly reaches the middle of the guides, the left engine is exhausting on the backward stroke, and when

the crosshead nears the forward end of the guides, the right engine exhausts on the forward stroke.

When the valve is in the position shown in Fig. 52, the front steam port C is uncovered and steam is admitted to the front end of the cylinder, indicated by

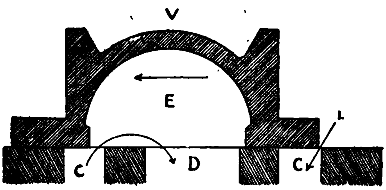


Fig. 52.

the arrow, and forces the piston toward the back end, or in the direction of the arrow. Fig. 53 shows the valve at its extreme travel with full port opening. The operation of the piston valve is similar to that of the slide-valve, except that a piston valve works in a bushing instead of on a flat surface.

When the piston reaches the back end of the cylinder, the valve has been moved to the position shown in Fig.

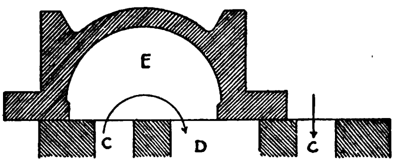


Fig. 53.

54, the back steam port C will be uncovered and steam will be admitted to the back end of the cylinder, indicated by the arrow. At the same time the front steam port C and the exhaust port D are both uncovered by the cavity E in the slide-valve so that the steam which

was admitted to the front end of the cylinder can now escape, as indicated by the arrow, through steam port C, into exhaust port D and thence to the atmosphere. By the movement of the slide-valve alternately back and forth, steam is simultaneously admitted to one end of the cylinder and exhausted from the other, and vice versa.

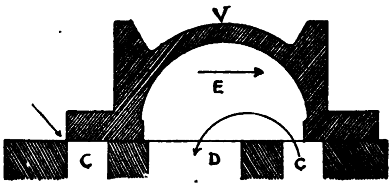


Fig. 54.

BALANCE SLIDE-VALVES.

A balance slide-valve is a valve so constructed that a certain percentage of the top surface of the valve is excluded from steam-chest pressure. Plate 10 (Fig. 1) shows a Richardson balance valve as it appears inside the steam-chest. Fig. 2 shows the top of the valve with one strip and spring removed.

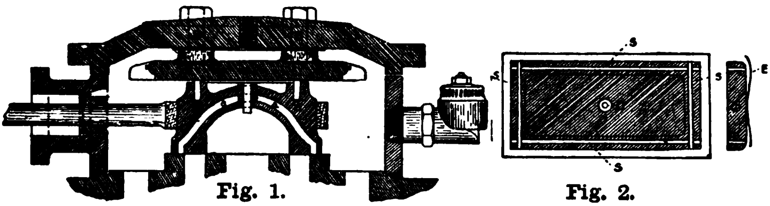


Fig. 1. Fig. 2.

Plate 10.

The balance feature of the valve is obtained by a plate (Fig. 1) which extends beyond the extreme travel of the valve, and is bolted to the steam-chest cover by bolts BB.

The purpose of the balance valve is to lessen the wear and the strain on the valve gear, reduce the consumption of oil and assist in making the handling of the reverse lever more easy, in addition to increasing the power of the engine.

The Allen-Richardson Valve. The Allen-Richardson valve has its valve grooved for the reception of four snugly fitting strips SS, which are supported against the balance plate by semi-elliptic spring E (Fig. 2) which forms a steam-tight joint and prevents any pressure from reaching the inclosed part of the valve shown in Fig. 1.

American Balance Valve. The American balance valve obtains the same result, but uses circular tapering rings. Fig. 56 shows one ring A removed from disk B. These rings are fitted on a cone-shaped disk B, and are a spring within themselves. When the steam is admitted to the chest, it exerts a pressure on the entire outside face of ring A. This causes the ring to press more firmly

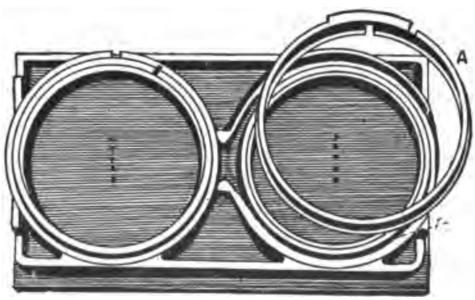


Fig. 56. Double Cone American Balance Valve.

against the cone and balance plate, making a steam-tight joint. A balance plate is used with this style of valve which is similar to that shown in Plate 9.

The hole D is drilled through the top of the valve

to allow any steam passing by the strips or rings to escape to the exhaust, without destroying the balance feature of the valve.

The Allen Ported Valve. With the plain slide-valve it has been found difficult in short cut-offs to get the full steam-chest pressure at the beginning of the stroke without excessive lead, and to overcome this difficulty the Allen ported valve (Fig. 57) was designed.

This valve has a supplementary port AA supplying steam to one steam port from both sides of the valve at the same time, thus giving double port opening for the same travel of the valve, and an increase of steam pressure in the cylinder. This valve has given excellent

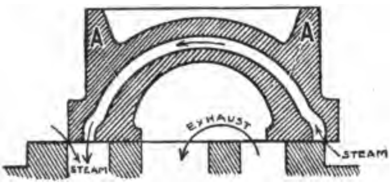


Fig. 57.

results, as it admits a good supply of steam at a high initial cylinder pressure with short valve travel, and it is especially adapted to high speed engines working in short cut-offs. This valve is of the "D" type.

PISTON VALVE.

The piston valve derives its name from its construction. It consists of two pistons PP, connected by a stem which is usually hollow (Fig. 58). The pistons have two or more packing rings which form the exhaust and steam edges of the valve. Packing rings 1 and 2 form the steam edges and rings 3 and 4 the exhaust edges.

Fig. 59 shows the piston valve in the bushing, and cylinder.

Fig. 60 shows a section through the saddle and cylinder. V represents the piston valve, C the cylinder, E the exhaust and S the steam passage.

Fig. 61 shows the piston valve bushing. The longitudinal strips or bridges are added to strengthen the bushing and to prevent the packing rings on the valve from springing past the edge of the port, while traveling over them.

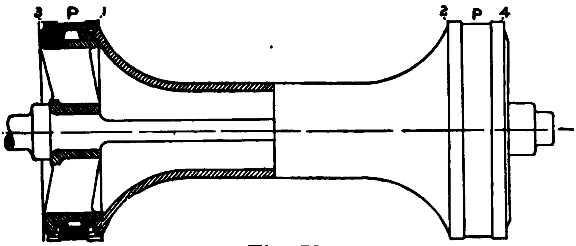


Fig. 58.

All piston valves are not alike, some being inside admission and outside exhaust, while others are outside admission and inside exhaust.

INSIDE AND OUTSIDE ADMISSION VALVES.

An inside admission valve is one in which the steam enters the steam port of the cylinder from the inside edge of the valve (Fig. 59) and is exhausted from the outer edge of the valve. Inside admission valves are of the piston type.

An outside admission valve is one in which the steam enters the steam port from the outer edge and is exhausted from the inner edge (Fig. 62.)

On an inside admission valve the motion of the valve is in the opposite direction to that of the piston motion at the beginning of the stroke (Fig. 59), while on an outside admission valve the movement of the valve is in the

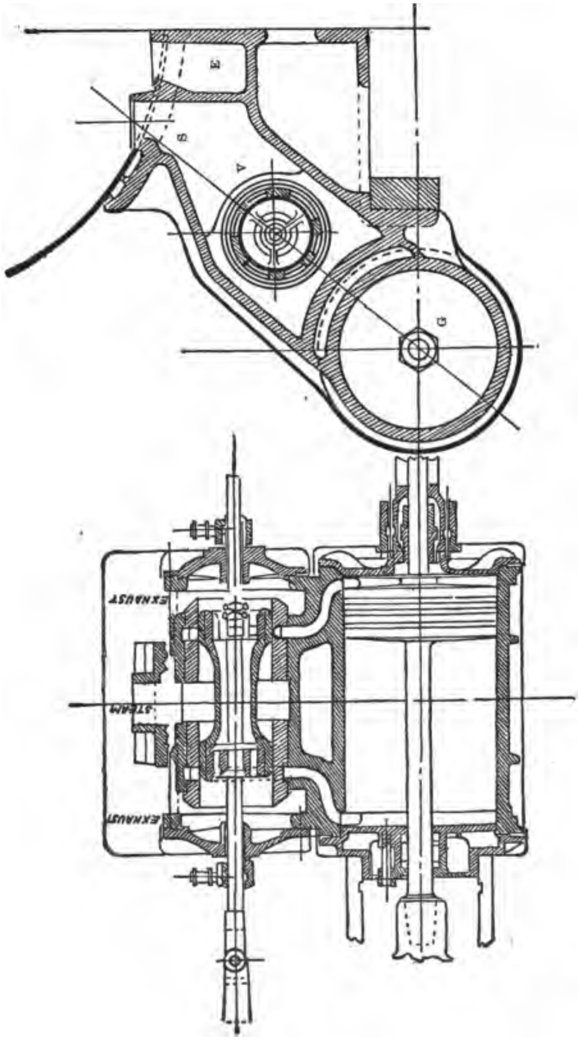


Fig. 59. **PISTON VALVE CYLINDER** Fig. 60.

same direction as that of the piston at the beginning of the stroke (Fig. 52).

LAP AND LEAD.

The width of the opening of the steam port to admit steam into the cylinder when the piston is at the begin-

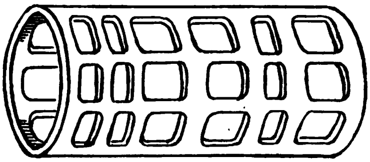


Fig. 61.

ning of the stroke (Fig. 52) is called the lead of the valve.

The valve is given lead in order that the steam port may have a greater opening at the beginning of the stroke of the piston, at the time when it is most needed. It also permits an earlier cut-off, in addition to providing a cushion against the piston as it nears the completion

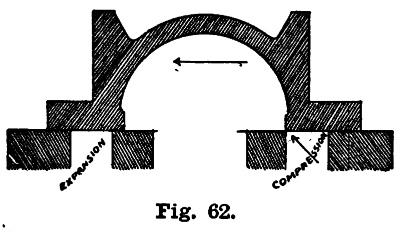


Fig. 62.

of its stroke, which prevents the lost motion in the reciprocating parts from causing the engine to pound.

The steam lap is that part of the valve which overlaps the inside edge of the outside bridge when the valve stands centrally upon the valve-seat. It is that

part of the valve marked "L" and is indicated by the space between lines M and M in Fig. 51.

The exhaust lap is that part of the valve which overlaps the outside edge of the inside bridge of the valve-seat when the valve stands centrally on its seat, as shown in Fig. 51 and indicated by the space between lines P and Q.

A valve is given lap for the purpose of hastening the cut-off, and enables the engine to work steam expansively.

DIRECT AND INDIRECT MOTION VALVE GEARS.

Both outside and inside admission valves have either direct or indirect motion, according to the position of

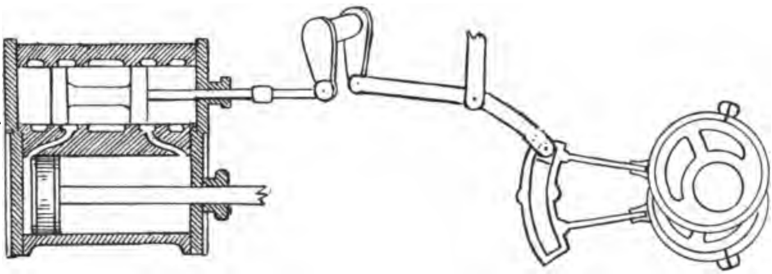


Fig. 63.

the eccentrics on the shaft and the type of rocker arm used.

A direct motion valve gear (Fig. 63) is one which transmits the motion of the eccentric to the valve direct by means of the transmission bar and the rocker shaft, upon which both rocker arms hang suspended and move in the same direction.

An indirect motion valve gear (Fig. 64) is one in which the power is transmitted from the eccentric to the lower rocker arm, which by its motion forward forces

the upper rocker arm backward so that the travel of the eccentric is opposite to that of the valve.

STEAM EXPANSION.

Working steam expansively is the process by which steam is admitted to the cylinder and cut off (Fig. 62) before the piston has completed its full stroke, thereby allowing the expansive force of the steam to exert its

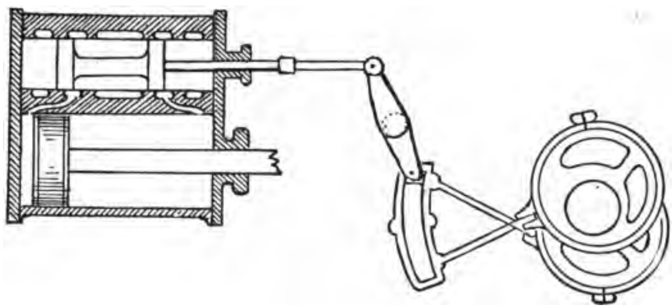


Fig. 64.

energy upon the piston from the time the cut-off takes place up to a point where the steam is released. The distance the valve travels during the expansion of the steam equals the total of the outside and inside laps of the valve.

EXHAUST CLEARANCE.

The exhaust clearance is the space between the inside edge of the exhaust arch and the outside edge of the exhaust bridges when the valve stands centrally on its seat, indicated by the space between lines O and P (Fig. 51).

COMPRESSION.

Steam pressure which does not pass out of the cylinder during the time the exhaust port is open is

entrapped in the cylinder, shown in Fig. 62, and indicated by the arrows. When the valve is in this position the inside edge of the valve closes the back steam port to the exhaust. The exhaust steam which is entrapped in the back end of the cylinder is compressed by the piston on its return stroke. This is called the point of compression. It will be seen that both steam ports are now covered by the valve shown in Fig. 62. The compression will continue to increase until the piston has completed its stroke. With cylinders which are not equipped with relief valves, when the compression becomes greater in the cylinder than the pressure in the steam-chest, it will force the valve off its seat and relieve the cylinder of its excessive pressure.

PREVENTING BREAKDOWNS AND ACCIDENTS.

Breakdowns and accidents are prevented by a thorough and careful inspection of the engine before leaving the roundhouse; also by making a thorough inspection each time when oiling.

An engineman should set up the wedges or see that they are properly set up by the roundhouse man, key up all rod brasses, see that all nuts and bolts are tight, that all bearings are properly packed and lubricated, keep the headlight clean, put in any required lubricator and water glasses, keep all boiler attachments in the cab well packed, do such work on the road as is necessary to insure a successful trip, and report all necessary repairs which should be made to the engine at the terminal.

BREAKDOWNS.

Locating Broken Valve, Valve-Stem or Yoke. If a valve, valve-stem or yoke is broken inside of the steam-chest, the breakage can be located by placing the engine at the half stroke, plumbing the rocker arm, opening the cylinder cocks and admitting a little steam to the chest.

If the steam blows to the stack at any position of the reverse lever, it indicates that the valve is broken in such a manner that steam is admitted into the exhaust cavity. If the steam appears at one cylinder cock only, and can be shut off from that end of the cylinder by moving the reverse lever, it indicates that part of the valve is broken off. If while moving the reverse lever from full forward to back gear, the steam steadily appears from one cylinder cock, it indicates that the yoke or stem is broken, and if the steam escapes alternately from both

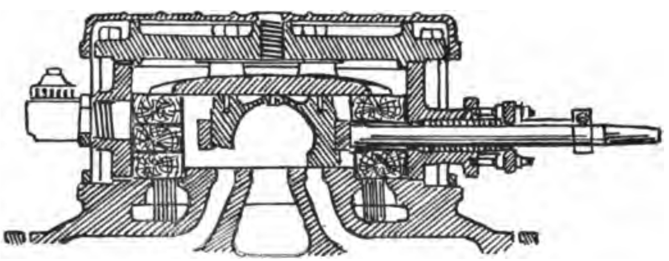


Fig. 65.

cylinder cocks or can be shut off from the cylinder entirely, it will be necessary to test the engine on the opposite side in the same manner.

Blocking for Broken Valve. If the valve is broken through into the exhaust cavity, the steam-chest cover

should be removed and the supply ports to the steam-chest blocked. Build up on these blocks, and hold them in place by fastening down the steam-chest cover, take down the main rod (unless all pieces of the broken valve have been found and removed) and block the crosshead,

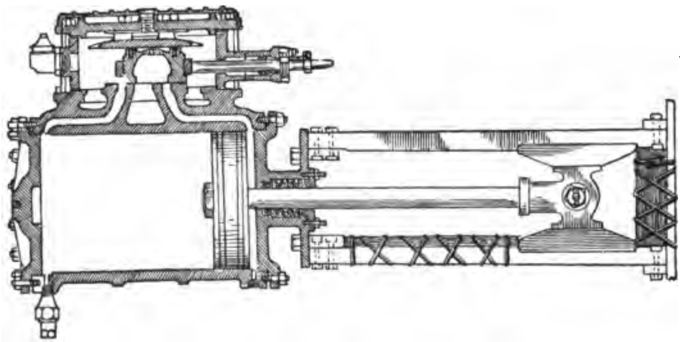


Fig. 66.

as some of the pieces of the broken valve might work into the cylinder and do further damage if the main rod were left up (Fig. 65).

Lap of Valve Broken. If the lap of the valve is broken off, the engineman should place the valve so that one admission and one exhaust port are covered, disconnect the valve-stem, and clamp the valve there securely. Next take down the main rod, and block the crosshead back when possible to do so, using the best of blocks. As an extra precaution, take out the back cylinder cock or block it open (Fig. 66).

Valve-Stem or Yoke Broken. If the valve-stem or yoke is broken and the relief valve is in the front end of the steam-chest, the rocker arm should be plumbed, the valve-stem disconnected, the relief valve taken out, the valve moved back against the valve-stem and suitable blocking inserted against the valve on the opposite

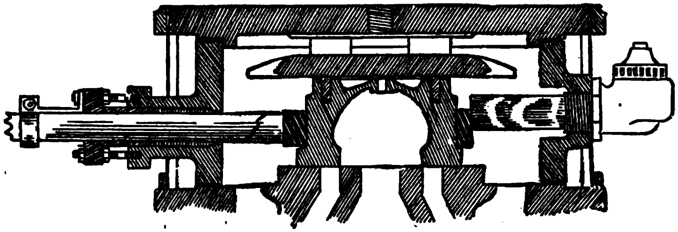


Fig. 67.

side. This blocking should be secured by screwing the relief valve back into the steam-chest (Fig. 67). If the relief valve is located in the back end of the steam-chest the valve should be moved ahead against the steam-chest

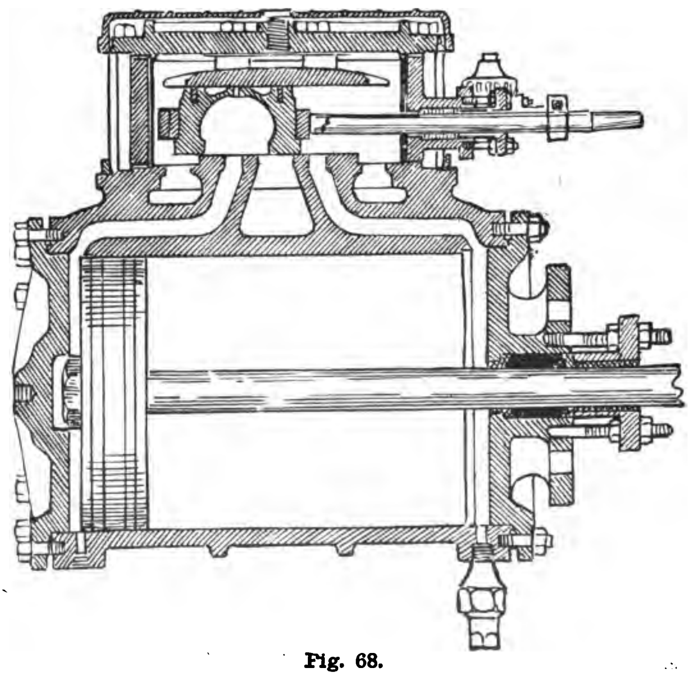


Fig. 68.

and steam admitted to the chest. If there is no blow at the stack, the valve should be secured in that position by clamping the valve-stem, the main rod taken down and the crosshead blocked ahead; the front cylinder cock should be removed or blocked open (Fig. 68).

If a blow occurs at the stack with the valve at the front of the chest, the steam-chest cover must be taken up, and the valve placed centrally on its seat, and secured in that position by the valve-stem and a block of wood placed in front of the valve and chest (Fig. 69).

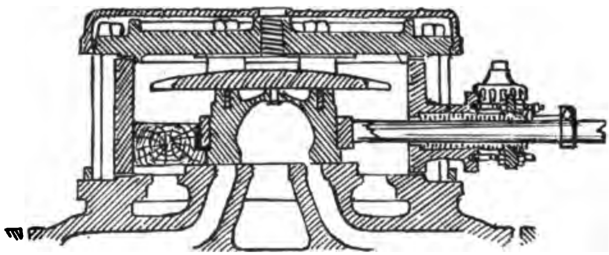


Fig. 69.

Piston Valve-Stem Broken. If the valve-stem of a piston valve breaks, the rocker arm should be plumbed, the valve-stem disconnected and clamped securely in position, the front steam-chest head then taken off and the valve shoved back against the stem and blocked between valve and head.

Piston Valve Broken. If the piston valve is broken, the steam-chest head should be taken off and the valve, if it is not too badly broken, placed centrally on its seat and blocked from the head to the valve to prevent it from moving ahead. The valve-stem should also be disconnected and clamped against the valve to keep the latter from moving back. If clamping the valve-stem fails to keep the valve together, the back head should be

removed and clamped with blocks in the same manner as the front head (Fig. 70). If the valve is broken so badly that steam cannot be kept from the exhaust, the engine should be prepared to be towed in.

Broken Valve-Seat. If the valve-seat is broken, and it is a front admission bridge and the admission and

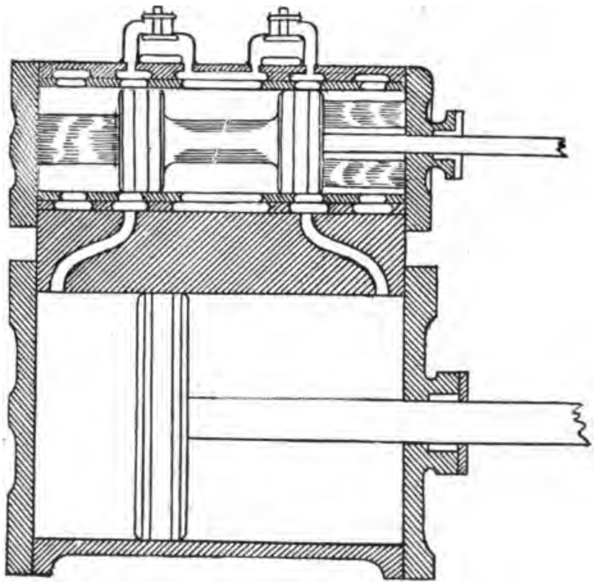


Fig. 70.

exhaust ports can be covered (Fig. 71), the valve-stem should be disconnected and clamped there securely, the connecting rod taken down and the crosshead blocked back.

But if it is the back admission bridge, the valve should be moved ahead in a position just opposite to that shown in Fig. 71, the crosshead blocked ahead and the cylinder cock removed from the end of the cylinder in

which the piston is blocked. When blocked in this manner, one end of the cylinder is connected to the steam-chest, which will admit steam to the cylinder and against the piston head. Good blocking should always be used.

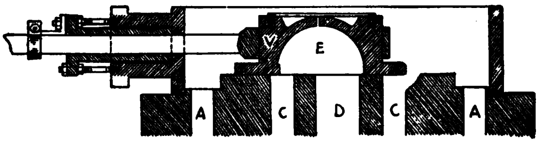


Fig. 71.

The removing of the cylinder cock will allow steam to pass out of the cylinder if the valve should shift, and will indicate that the valve has moved from its position.

If the cylinder cock were not removed and the throttle shut off, the pressure on one side of the piston would quickly escape and the pressure which had accumulated back of the piston would shift the piston and crosshead, causing further damage when the throttle was again opened.

Broken Exhaust Bridge. If the exhaust bridge becomes broken, the valve should be placed centrally on

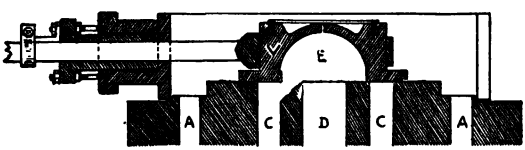


Fig. 72.

its seat, the valve-stem disconnected and clamped securely in place (Fig. 72), the main rod taken down, and the crosshead blocked back. The reason why the main rod should be taken down is that pieces of the seat

might work down into the cylinder and do further damage.

Both Bridges Broken. If both the exhaust and admission bridges are broken, the steam-chest cover should be taken up and the supply ports to the chest blocked. This blocking must be built up until the steam-chest cover, when replaced, will hold the blocking securely in place (Fig. 65). The main rod may be left up if all the pieces of the broken valve-seat can be found,

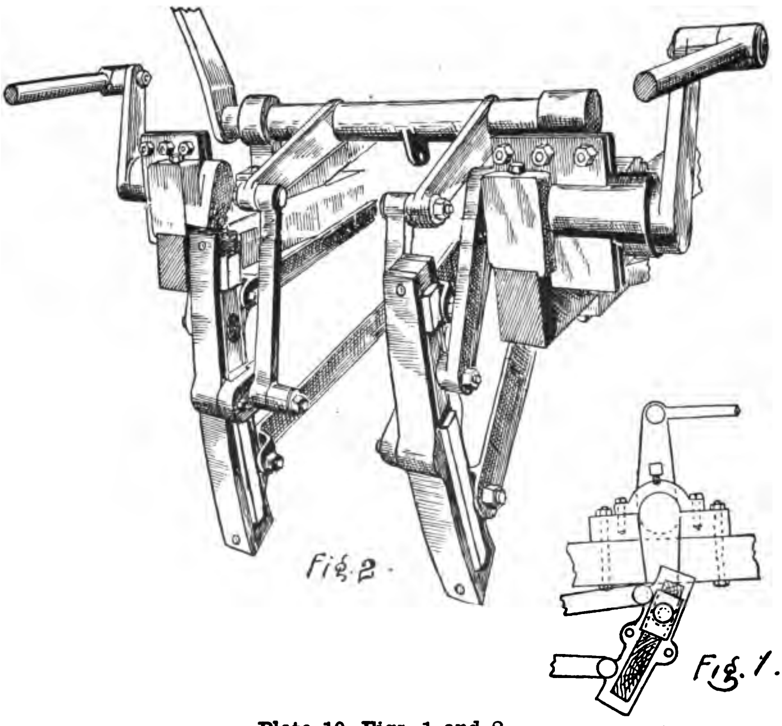


Fig. 2.

Fig. 1.

Plate 10, Figs. 1 and 2.

otherwise it should be taken down and the crosshead blocked back, as shown in Fig. 66.

Breakage of Reversing Arm, Reverse Lever or Reach-Rod. If the reversing arm, reverse lever, or reach-rod breaks, one link should be blocked solid, both top and bottom, at the point of cut-off, which will enable the engine to handle the train over the division. This method of blocking is shown in Fig. 1, Plate 10. Some roads prefer that both links should be blocked at both top and bottom (Fig. 2, Plate 10). For the forward motion a small block is placed on top of both link blocks, and a long block under the link block in the bottom of the link, and so fitted that there will be three-quarters of an inch of play to accommodate the slip of the link block. If the engine is to be used in the back motion, the long blocks should be placed on the top of the link block, and the short ones on the bottom of the link. These blocks should be fastened securely in their places by means of bell cord or wire.

Broken Transmission Bar or Hanger. To disconnect for a broken transmission bar, the broken parts should be removed, the valve placed centrally upon its seat and the valve-stem disconnected and clamped securely.

If a transmission bar hanger is broken, block the link solid on the top and bottom at the point of cut-off, which will enable the engine to handle the train over the division (Fig. 1, Plate 10).

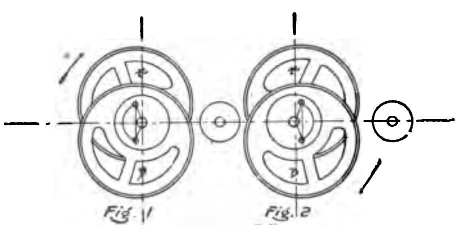


Plate 11, Figs. 1 and 2.

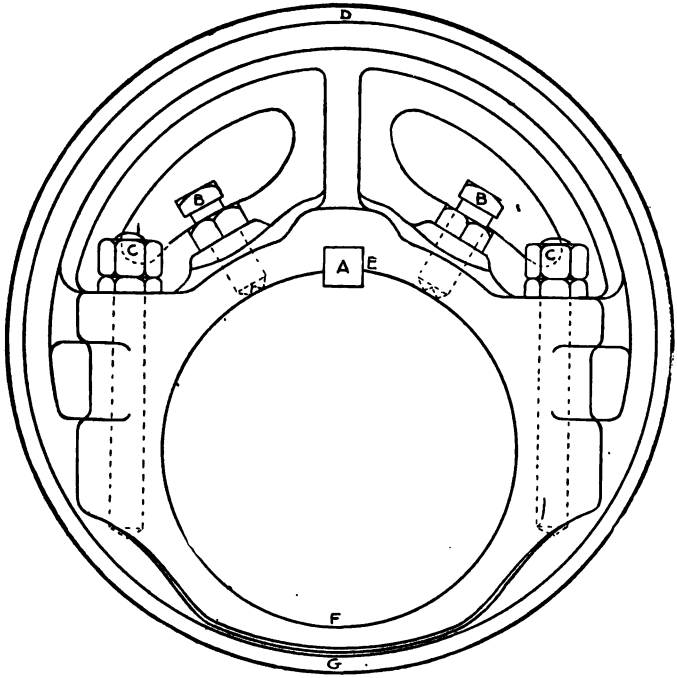


Fig. 73. Eccentric.

BY-PASS VALVES.

A by-pass valve BB (Fig. 75) is a small valve, one of which is placed on each end of the steam-chest for the purpose of preventing excessive pressure. They are connected with the live steam side of the valve EEE and the steam port between the valve and cylinder FF. They are held to their seats by the steam-chest pressure and are unseated when the compression in the cylinder becomes greater than the boiler pressure.

If a by-pass valve is broken it should be tested for by

covering the exhaust port with the main valve. If the blow then ceases and steam appears at the cylinder cock it indicates a broken by-pass valve, and the cylinder cock which shows steam will indicate which valve is broken. A broken by-pass valve will cause a heavy blow at the stack when the exhaust is open. Fig. 75 shows the back end of the cylinder open to exhaust, and also shows how steam can pass from E to F and out of the stack in case the back by-pass is broken.

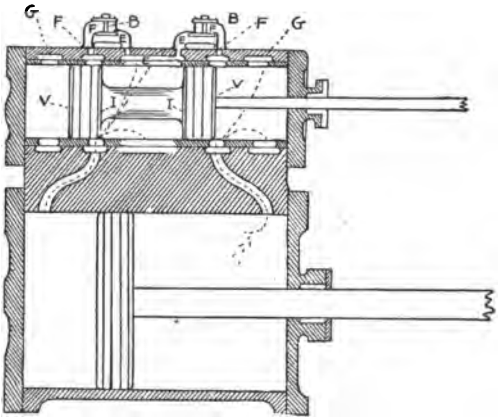


Fig. 75. Showing Piston Valve and Cylinder By-Pass Valves, Placed on Top of Steam Chest

CYLINDER PACKING.

Cylinder packing is fitted into grooves provided for that purpose in bull ring B (Fig. 77). Its purpose is to form a steam-tight joint between the wall of the cylinder and the piston. The bull ring is held in place by the spider and follower, which in turn is held in its place by studs screwed into the face of the spider.

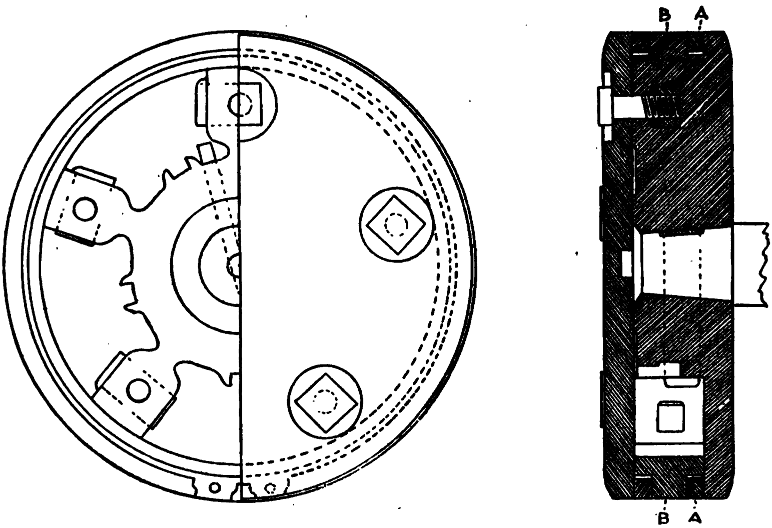


Fig. 77.

Cracked or Broken Steam-Chest. A cracked or broken steam-chest is usually caused by reversing the engine when running at a high rate of speed, with the throttle closed. This causes the cylinders to become air compressors. High pressure is forced into the steam-chest, and, having no means of escape, accumulates at a higher pressure than the steam-chest is designed to withstand. Modern locomotives are provided with steam-chest relief valves for the purpose of relieving excessive pressure and eliminating the possibility of steam-chest ruptures.

When a steam-chest is cracked and it is not too serious to interfere with the running or steaming of the engine, or the vision of the engineman is not obscured, the train should proceed. If, however, the crack is large enough to interfere with the running or steaming of the engine, the oil pipe should be taken off, the casing removed, the nuts holding the steam-chest cover in place slackened up and iron

wedges or nails inserted between the studs and steam-chest in such a manner as to wedge the broken parts together. The nuts holding the steam-chest cover should then be tightened, securing the cover in place (Fig. 78), and the casing and oil pipe replaced. If the studs are inside or pass through the steam-chest, a chain should be placed around the chest and wedges driven between the chain and chest. This will draw the steam-chest together and prevent the steam from escaping.

If the steam-chest breaks, the broken parts should be removed, the supply ports to the steam-chest blocked with

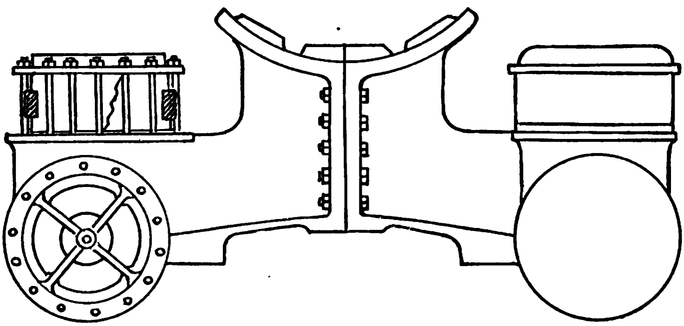


Fig. 78.

dry pine, and wooden blocks used to build up on the blocking. If there are enough studs left on the steam-chest, a fish plate can be placed across the blocking to hold it in place (Plate 12, Fig. 1). If there are no studs left, a jack, chain and wedges should be used for holding the blocking in place (Fig. 2, Plate 12). If this cannot be done it will be necessary to have the engine towed in.

Broken Piston Rod. If a piston rod breaks off close to the piston head or close to the crosshead, and it has not knocked out the front cylinder head, the head should be

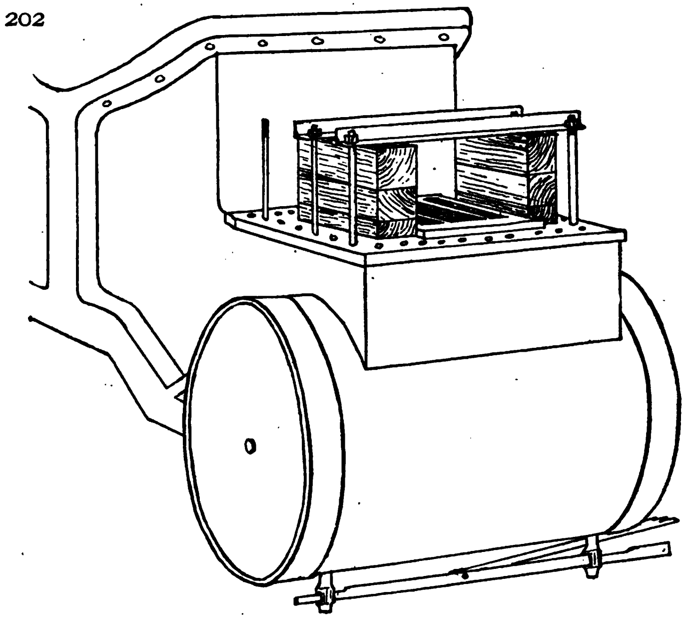


Fig. 1.

Plate 12.

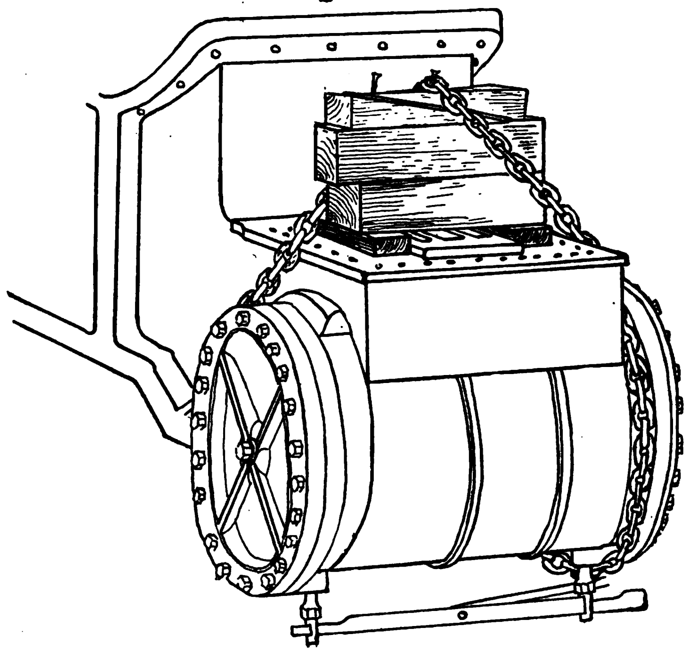


Fig. 2.

taken off and the piston removed from the cylinder, leaving the main rod intact.

Broken Rocker Arm. When a lower rocker arm becomes broken, the arm should be plumbed and the valve-stem disconnected and clamped with the valve on the center of the seat. The arm may remain in place provided it does not strike any other part of the engine.

Broken Eccentric, Strap or Blade. If the back-up eccentric, strap or blade is broken, the broken parts should be disconnected, the reverse lever placed in the full forward gear, and the train taken to the nearest siding. The go-ahead strap and blade should then be taken down, the valve placed centrally on its seat, the valve-stem disconnected and clamped securely, but the main rod is not to be disconnected. If the go-ahead eccentric, strap, or blade should break, take down the broken parts, take off the back-up eccentric strap and blade, and clamp the valve as above described.

If the main rod on the disabled side of the engine is not taken down, the cylinder should be lubricated by removing the indicator plug, if the engine is so equipped, oiling the cylinder, and replacing the plug. If the engine has no plugs, the front cylinder head should be wedged open, or the valve shifted just enough to show a little steam at the cylinder cocks, and the cylinder oiled with the lubricator.

Broken Link Saddle Pin, Link Hanger or Lifting Arm. If a link saddle pin, link hanger or lifting arm is broken, the broken parts should be removed, and the link blocked in the same manner as for a broken transmission bar hanger.

If the link hanger is broken, the broken parts should be removed and the link blocked solidly, both top and bottom, at the point of cut-off, which will enable the engine to handle the train over the division with one link blocked up. Care must be taken not to drop the reverse lever low

enough to allow the lifting arm to pass beneath the link which is blocked. On an engine with the tumbling shaft below the frame, care should be taken not to raise the lifting arm high enough to pass behind the link. In both cases the engineman should guard against reversing the engine by fastening the reverse lever at the quadrant, either by a set-screw, by tightening up on the ratchet, or by placing a block in the opposite link.

To disconnect for a broken link block pin, the valve should be placed centrally upon its seat, the valve-stem disconnected and clamped, as shown in Fig. 72, and the rocker arm swung so that the link will not strike it. If this cannot be done, the rocker arm should be removed if possible; if not, it would be necessary to take down the eccentric straps and blades from that side and tie the link in order to prevent it from swinging.

Broken Crosshead. If a crosshead breaks, the main rod should be taken down, the valve-stem disconnected, and the valve clamped centrally on its seat. If enough of the crosshead is left to block it securely, this should be done. If not, the piston should be removed from the cylinder.

Bent Pin, Main or Side Rod. If the main rod is badly bent, or the main pin bent, the rod should be removed, the valve clamped, the crosshead blocked, and, if the side rod is left on, a collar should be placed on the pin to keep the rod in place. If the side rod is left up the keys should be slacked up. If there is danger of its running hot, however, it should be taken down and the engine brought in light with one main rod up.

Broken Front End. An engine with a broken front end can be brought in by boarding up the opening, protecting it with the cab curtain or filling it up with strips of sod.

An empty barrel could be placed over the smoke arch of an engine with a broken stack, and would serve to bring the engine in light.

BROKEN OR BURNT GRATES.

If the grates are burned out or become broken on the road, they should be blocked with brick, fish plates or anything else available for the purpose, if they are not too badly broken or burned. If the grates are entirely gone the engine will have to be towed in.

BROKEN DRIVING OR TRUCK CELLAR.

If a driving box cellar, its lugs, or an engine truck cellar is broken, a temporary one should be made out of wood, and a piece of rubber hose tied to the binder to hold the cellar against the journal. The rubber hose will act as a spring for the upward and downward movement of the boxes.

BROKEN ENGINE TRUCK WHEELS.

If a piece breaks out of right No. 1 engine truck wheel, a suitable fulcrum should be used, one end being placed on a tie and the other end up under the journal. This fulcrum should be placed as close to the box of the disabled wheel as possible, and the engine moved so as to raise the wheel. The good wheel on the opposite side of the engine being in contact with the rail, will, in turning, bring the good part of the broken wheel to the rail. The wheel should then be

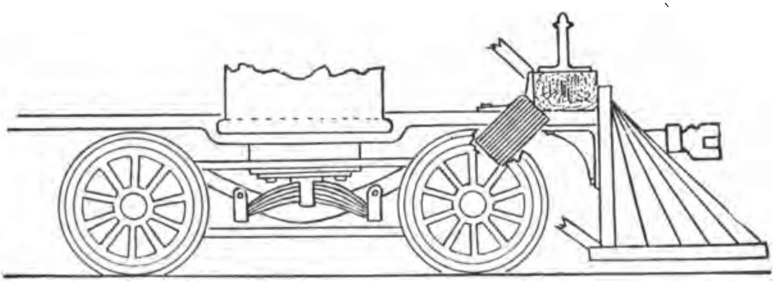


Fig. 80.

secured by means of a wedge or chain to keep it from revolving (Fig. 80). The wheel can then be skidded to the nearest siding, and an extra pair of wheels and men to put them in sent for.

BROKEN ENGINE TRUCK AXLE.

If the axle is broken outside of the box, a chain should be placed around the engine and truck frames, a fulcrum

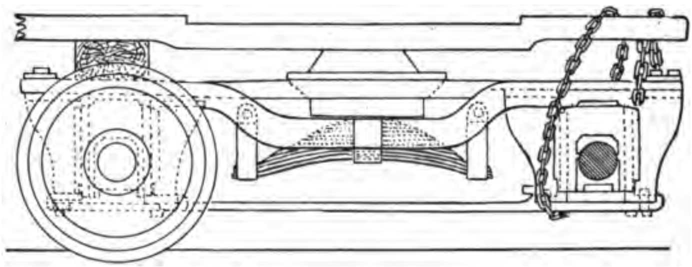


Fig. 81.

placed under the buffer beam (commonly called pilot beam) and against a good tie and the engine moved back. This will raise both the engine and truck frames. Blocking should then be placed between the ground and the pedestal brace of the engine truck, the main frame lowered and the truck frame allowed to rest on the blocking, thus allowing the slack of the chain to be taken up. The engine frame should then be raised in the same manner, bringing the truck frame a little higher than its normal position. The chain should then be crossed from the truck frame on the disabled side to the engine frame on the opposite side. This is done for the purpose of keeping the good flange against the rail. Blocking should also be placed between truck and engine frames on right and left No. 2, for the purpose of holding up the right front corner of the engine truck frame (Fig. 81).

BROKEN PONY TRUCK AXLE.

If the journal on the pony truck of a Mogul engine is broken, the pilot beam should be fulcrumed up, thus raising the engine frame, the pony truck wheels removed, and blocking inserted between the bottom of the boiler and the top of the cross equalizer. Blocking should also be placed over the front driving boxes (Plate 13, Fig. 1), after which the engine can proceed very slowly. If the pony truck cannot be removed, the engine frame should be raised in the manner described, the pony truck frame should be chained to the engine frame on both sides and blocked between the tops of both forward driving boxes and the

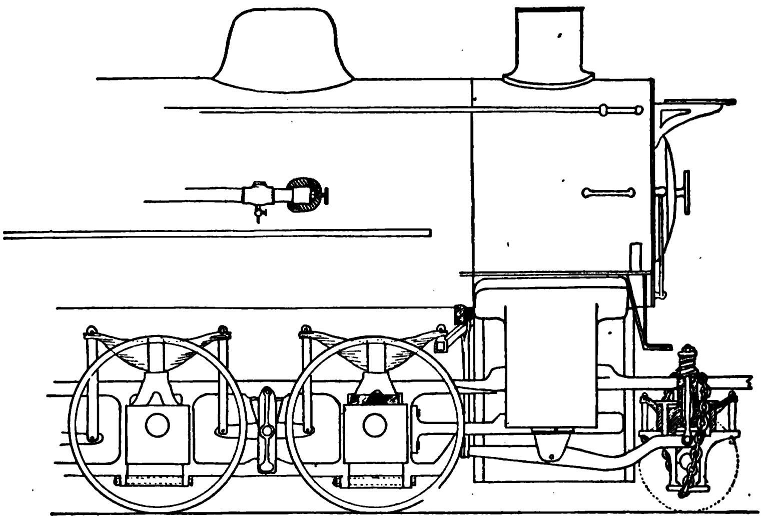


Fig. 1, Plate 13.

lower surface of the engine frame, also blocking between the top of the cross equalizer and the bottom of the boiler (Fig. 2, Plate 13).

If an engine truck wheel or axle is broken on a consoli-

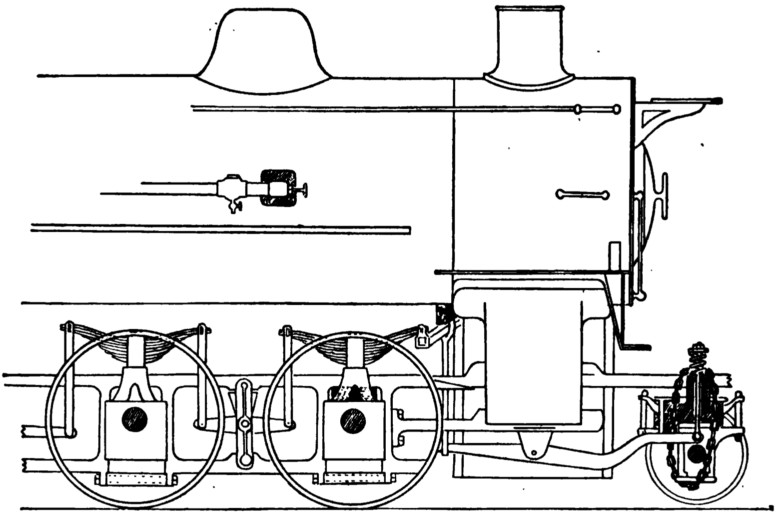


Fig. 2, Plate 13.

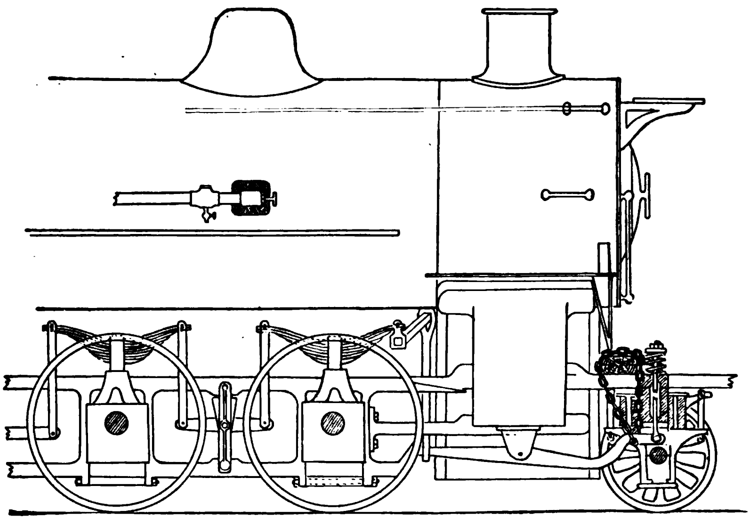


Fig. 3, Plate 13.

dated or ten-wheel engine, the engine truck frame can be chained to the main frame, as described, but instead of using a fulcrum under the pilot beam, the forward drivers should be run up on wedges, which would raise the engine truck for the purpose of chaining it for a double truck or axle (Fig. 81).

BROKEN PONY TRUCK CENTER PIN, EQUALIZER OR HANGER.

In case the center pin of a pony truck or the front end of a long equalizer should break, place a fulcrum under the forward end of the long equalizer and move the engine back, raising the front end of the long equalizer higher than its normal position. Then place a tie across and on top of the main frame and chain the front end of the long equalizer to the tie and remove the broken parts, allowing the truck to remain, as shown in Fig. 3, Plate 13.

If the long equalizer is broken at the fulcrum, place a fulcrum under the pilot beam, moving the engine in either direction, thus raising the main frame, which will free the spring rigging. Then place a block between the lower part of the boiler and the cross equalizer. If the pilot does not clear the rail sufficiently after letting the engine down, blocking should be placed on top of both forward driving boxes. The blocking could be placed over the front driving boxes by running No. 2 driver on a wedge instead of fulcruming up the front end (Fig. 4, Plate 13).

If the back hanger of the long equalizer is broken, place a fulcrum under the pilot beam so as to insert a block between the cross equalizer and the lower part of the boiler, in order to bring the cross equalizer to normal position. Then move the engine off the fulcrum and place a fulcrum under the back end of the long equalizer and move the engine ahead; fulcrum up the back end of the equalizer higher than its normal position; then chain from the back

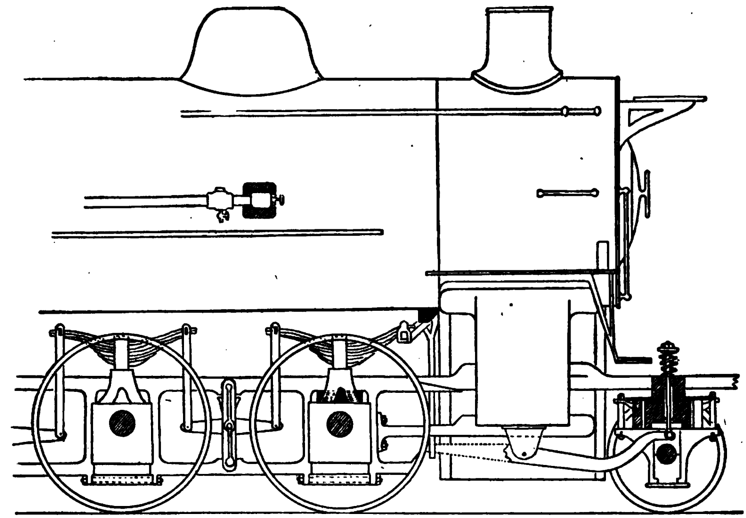


Fig. 4, Plate 13.

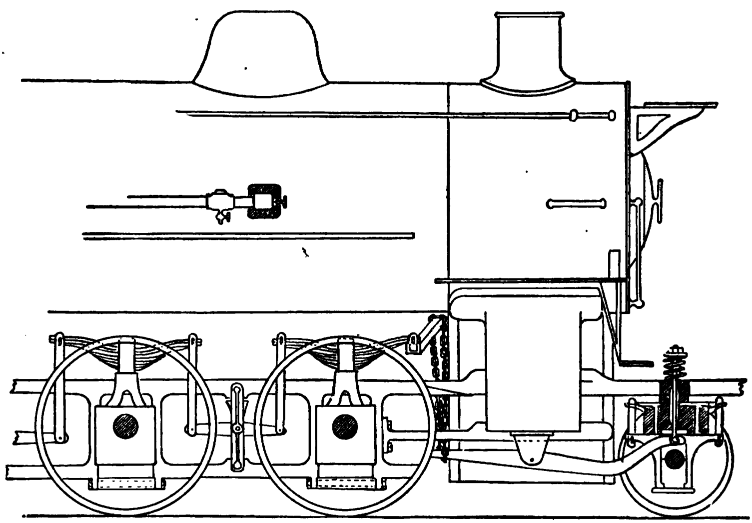


Fig. 5, Plate 13.

end of the long equalizer to the cross equalizer and remove the block on top of the cross equalizer and underneath the boiler (Fig. 5, Plate 13).

BROKEN TENDER TRUCK WHEEL.

If a piece breaks out of a tender truck wheel, a tie or frog should be placed in a slanting position under the tank truck box or some part of the tender truck frame and blocked in such a manner as to hold it in this position. The engine should then be moved sufficiently to skid that side up high enough for the flat part of the wheel to clear the rail, after which the wheel on the opposite side is allowed to turn, bringing the broken part of the wheel to the top. It should then be blocked in the same manner as for an engine truck wheel (Fig. 80). These wheels can then be slid to the nearest siding and a new pair of wheels ordered to replace the old ones.

BROKEN TENDER TRUCK JOURNAL.

If a journal is broken outside or inside of the wheel, a tie or frog should be placed in a slanting position on each side, under the tank truck boxes or the truck frame of the broken journal. By moving the engine, both sides can be

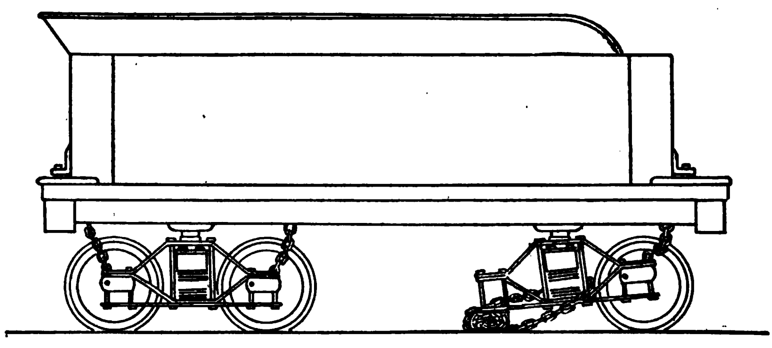


Fig. 83.

skidded up at the same time. When the truck frame is raised sufficiently, an oak tie should be placed on top of the rails and under both sides of the truck frame, just ahead of or behind the pair of wheels with the broken journal. The truck frame should then be let down, so that it rests on top of the tie, and secured with a chain. The wheels with the broken journal should then be removed or fastened in such a manner that they can do no further damage (Fig. 83), the tank skidded to the nearest siding and assistance sent for.

BROKEN TENDER TRUCK SPRING.

If a tender truck spring is broken, it will be necessary to fulcrum up the tank on the side or corner on which the spring is broken. If it is a semi-elliptic spring extending from one truck box to the other the blocking should be done between the top of the bolster and the bottom sill of the tank. If a swing truck, the blocking should be between the bolster and the sand board instead of the spring.

BROKEN ENGINE TRUCK SPRING OR EQUALIZER.

If an engine truck spring or equalizer is broken, one end of a fulcrum post of the proper length should be placed on a tie and the other end placed under the jaw of the engine truck frame on the side on which the spring or equalizer is broken, and the engine moved ahead or back. This will

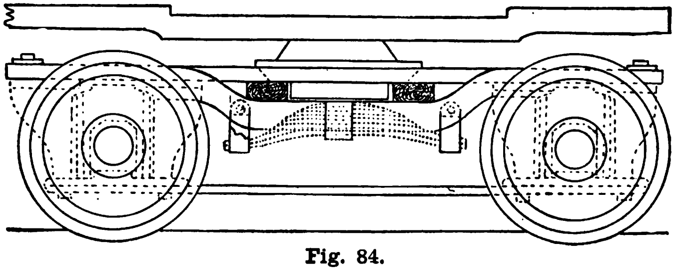


Fig. 84.

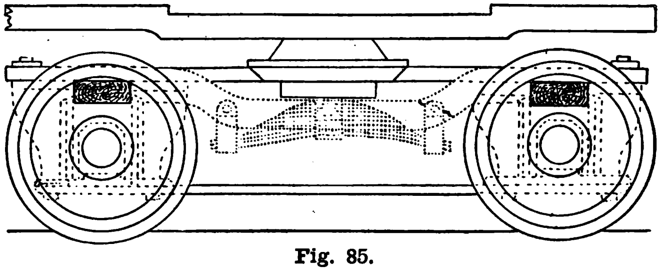


Fig. 85.

raise the corner of the engine truck frame higher than its normal position.

If the spring is broken a block should be placed on top of the equalizer and under the engine truck frame.

The opposite corner of the engine truck frame on the same side should then be raised in the same manner and blocks placed (Fig. 84).

If the equalizer is broken, the truck frame should be elevated in the manner just described and the blocks placed on top of the engine truck boxes and under the engine truck frame (Fig. 85).

BROKEN SIDE ROD.

If a side rod breaks on an eight-wheel engine the opposite rods to those which are broken should also be taken off. On a ten-wheel engine with the knuckle joint back of the main pin, if the back section of the rod breaks, it will be necessary to take down the opposite rod. If a forward section breaks on a ten-wheel engine all side rods must be taken down. If the forward or back section breaks on a consolidated engine the opposite rods should be taken down. If an intermediate side rod breaks all the rods must be taken down.

Some of the modern engines cannot run under their own steam with their side rods off. This is due to the tendency of locomotive builders to use long main rods and short

eccentric blades. To secure this result, the eccentrics are not placed on the main driving wheel axle, but on the one just ahead. Therefore with the side rods off, a slip of the main drivers would throw them out of line with the drivers carrying the eccentrics and the engine would have to be towed in. This type of construction is in use principally on switch engines which are seldom out on the road.

BROKEN ENGINE FRAME.

If a single frame is broken between the main driver and the cylinder, the disabled side of the engine should be disconnected and the engine taken in light. If it is a double frame and it does not open too far, the engine should take in as many cars of perishable freight as can be handled without further damage. If there is danger of further damage, the engine should go in light, being very careful when starting. If the lower rail of the frame is broken, start the engine and see how far it will open up, and if there is no danger of breaking the upper rail, proceed with a full train.

If the top rail of the frame is broken back of the main driver, the side rods should be taken down, and the engine can then proceed with as many cars as it can handle without further damage. If the break is in the lower rail the engine can proceed to the terminal with the entire train.

BROKEN DRIVING TIRES.

Forward Tire, Ten-Wheel Engine. If one of the forward tires of a ten-wheel engine breaks, the wheel should be run up on a wedge to raise it higher than the thickness of the tire, making allowance for settling, the cellar removed if possible, a block fitted in place of the cellar and a block placed between the bottom of the driving box and the top of the binder. If the cellar cannot be removed, a nut should be placed on top of the binder under each jaw of

the driving box, blocking placed between the binder cellar, and the front end of the front equalizer chained to the lower rail of the frame (Fig. 86). The reason for blocking in this manner when the cellar cannot be removed is, that if a block

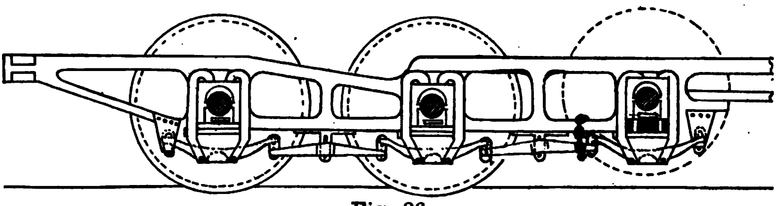


Fig. 86.

were placed on top of the binder the full width of the driving box, there being more weight on the driving box than on the cellar, and the cellar having more surface on the blocking than the driving box width, the driving box would gradually work its way into the wooden blocking, placing all the weight on the cellar and cellar bolts, which could not bear it. On heavy power where the pedestal is strong enough to carry the weight of the driver, it will not be necessary to chain the equalizer, but otherwise the equalizer must be chained as in Fig. 86, or with overhung spring rigging, a block placed in the spring saddle. If the side rods are not damaged they should be left up.

In all cases of broken tires the driver brake should be cut out. A full train can be handled when the break is on a front tire.

Middle Tire. If a middle driving tire breaks it will

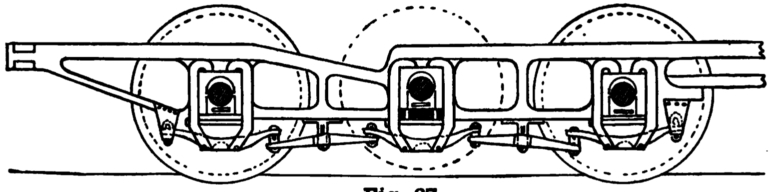


Fig. 87.

be necessary to block the engine in the manner described and as shown in Fig. 87, and to proceed without a train

Back Tire. If a back tire breaks the blocking should be done in the same manner as for a middle tire, but while the wheel is on the wedge, blocking should be placed on top of the driving box and under the frame on the driver ahead of the back driver, or if there is a chain on hand a tie should be placed from the deck of the engine to the deck of the tank, and a chain placed around the back end of the main frame on the disabled side, and around the tie. This style of blocking is shown in Fig. 91. It will also be necessary to build up between the bed of the tank and the tie in order to take up all lost motion of the chain, so that when the wheel is run off the wedge the chain or block on top of the driving box will hold up the rear end of the engine frame and prevent the driver from settling to the rail. Fig. 88 shows a block placed on the middle driving box and under the frame. While going around curves, a wedge or tie should be placed between the engine and tank on the inner side of the curve, or a chain placed from the disabled side of the engine frame to the tank frame on the opposite side. The purpose of the tie, wedge or chain is to prevent the good wheel on the opposite side from dropping off the rail. It will be necessary to proceed with caution while rounding curves and passing over frogs and switches.

Forward Tire, Eight-Wheel Engine. If a forward tire of an eight-wheel engine breaks, the forward driver should be run on a wedge considerably thicker than the tire

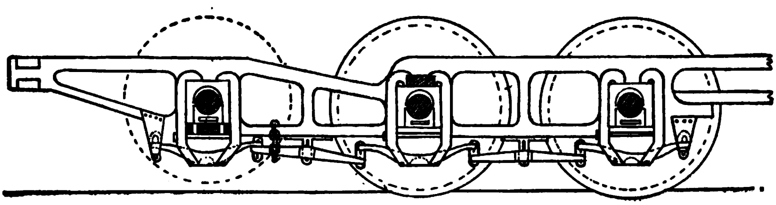


Fig. 88.

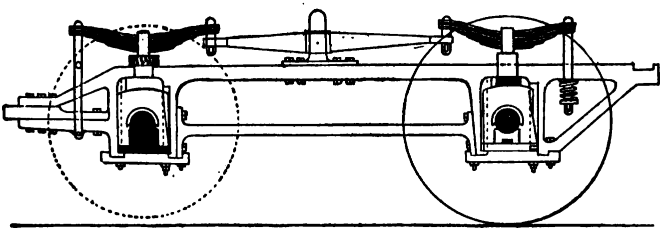


Fig. 89.

in order to allow for settling, the cellar removed and a block substituted, and the space between the pedestal brace and the cellar blocked up solidly (Fig. 89). If the engine is equipped with an overhung spring rigging, a block should be placed between the spring saddle and the top rail of the frame; if an underhung spring rigging, the forward end of the equalizer should be chained up. The weight on the driving box of all types of engines with a broken tire must be relieved, when the pedestal is not strong enough to withstand the weight. If the forward tire is broken on an engine having an underhung spring rigging, and the equalizer is chained up, a block should be placed over the back driving box to help carry the weight (Fig. 90).

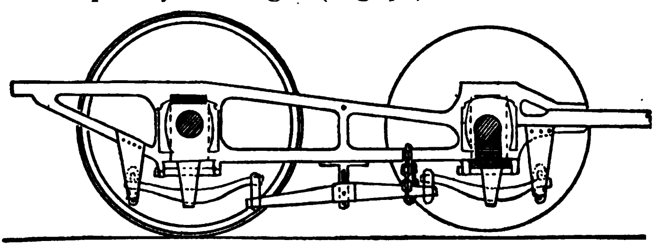


Fig. 90.

Back Tire, Eight-Wheel Engine. If a back tire on an eight-wheel engine breaks, it should be blocked up in the same manner as for the tire on a back driver of a ten-wheel engine (Figs. 88 or 91).

Trailer Tires. If a trailer tire breaks, run the wheel up on a wedge, a little higher than the thickness of the tire, remove the cellar and place a block between the bottom of

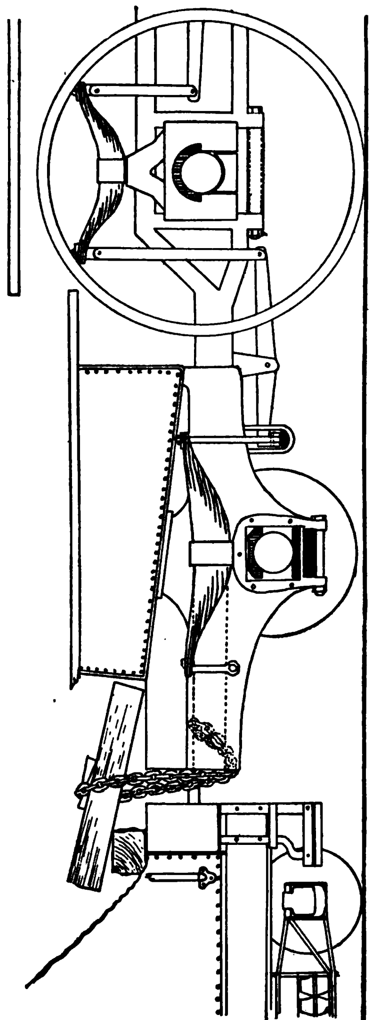


Fig. 91.

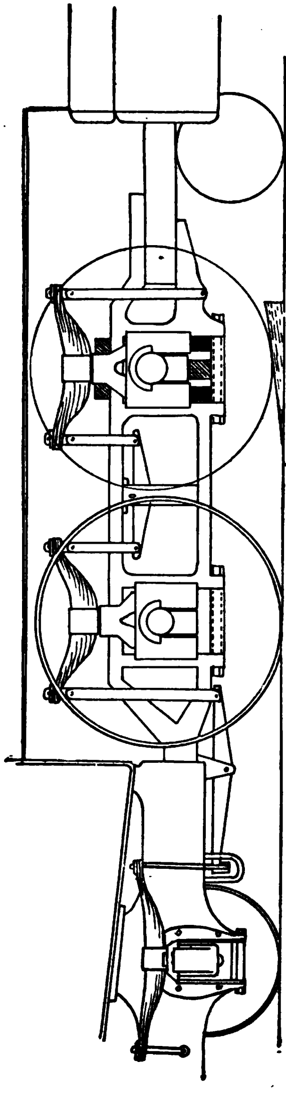


Plate 14, Fig. 1

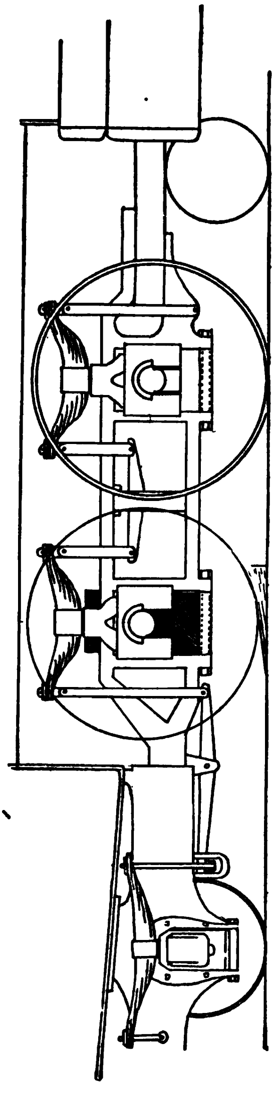


Fig. 2, Plate 14.

the journal and the box. A block should then be placed between the bottom of the box and the pedestal, the cross equalizer blocked up in the safety hanger, or the equalizer chained to the frame and a tie or rail placed over the deck of the engine and the deck of the tank and chained to the main frame (Fig. 91), wedges being used to take up the slack in the chain. This manner of chaining serves to hold up the back end of the engine and also to keep the good wheel to the rail while passing around curves.

Atlantic Type Forward and Back Driving Tires. If a front tire on an Atlantic type of engine is broken, the forward wheel should be run on a wedge, the cellar removed and a block inserted in its place. It should then be blocked solidly between the substituted cellar and the pedestal brace, and a block placed between the spring saddle and the frame. If the cellar cannot be removed, a nut or block of iron should be placed between the pedestal brace and the jaws of the driving box and blocks placed between the pedestal and the cellar to hold the cellar in place (Fig. 1, Plate 14). If the main tire is broken it should be elevated in the same manner (Fig. 2, Plate 14).

BROKEN SPRING, HANGER OR EQUALIZER—EIGHT-WHEEL ENGINE.

Forward Hanger or Spring. If the forward spring hanger, or the spring on an eight-wheel engine, with overhung spring rigging breaks, a block should be placed on top

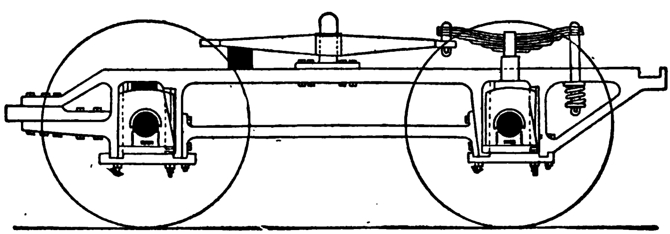


Fig. 93.

of the back driving box, if there is room, before raising the back driver. The purpose of this block is to raise the frame as high as possible with an ordinary wedge. A wedge should then be placed on the rail, the back driver run upon it, thus taking the weight off the forward box, and blocking inserted solidly between the forward box and the frame. The broken spring or hanger should then be removed, if necessary, and the engine run off the wedge. The forward driver should now be run on the wedge in order to relieve the equalizer, the front end of the equalizer pried up, and blocking placed between the forward end of the equalizer and the frame. The block should then be removed from the back driver, all loose parts taken away and the engine run off the wedge (Fig. 93).

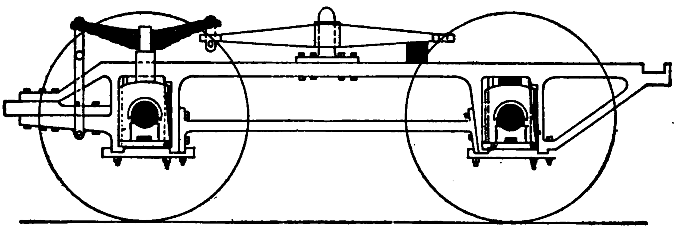


Fig. 94.

Back Spring or Hanger. If the back spring or hanger is broken the same method of blocking will apply, but in the reverse manner (Fig. 94).

Equalizer with Overhung Spring Rigging. If the equalizer of an engine with overhung spring rigging is broken at the fulcrum, the front driver should be run on a wedge, a block placed on top of the back driving box and the forward driver run down. The back driver should then be run on a wedge, a block placed on top of the forward driving box, all loose parts removed and the back driver run off the wedge (Fig. 95).

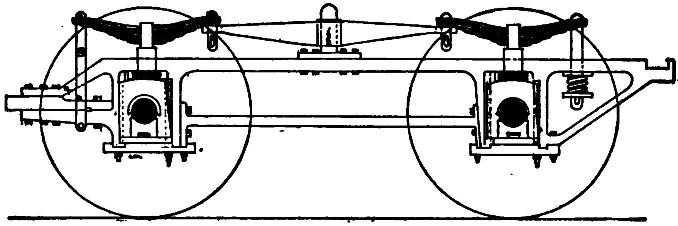


Fig. 95.

Forward and Back Spring with Underhung Rigging. If the front spring of an underhung eight-wheel engine is broken, the back driver should be run on a wedge, a block placed on top of the front driving box and the back driver run off the wedge. The front driver should then be run on a wedge, thus relieving the back spring rigging, the forward end of the equalizer pried up and chained to the lower rail of the frame, or the forward end of the back spring blocked down (Fig. 1, Plate 15) and the forward driver run off the wedge.

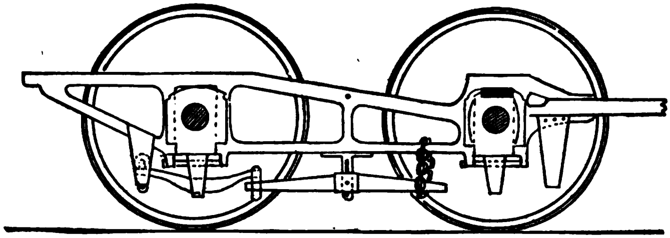


Plate 15, Fig. 1.

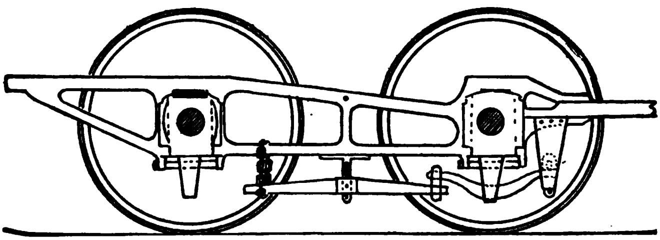


Fig. 2, Plate 15.

If the back spring is broken the engine can be elevated and blocked (Fig. 2, Plate 15) by proceeding in the reverse manner to that described for front spring (Fig. 1, Plate 15).

Equalizer Broken at the Fulcrum with Underhung Rigging. If an equalizer is broken at the fulcrum on an engine with underhung spring rigging the back driver should be run on a wedge, a block placed on top of the forward driving box and the driver run off the wedge. The forward driver should then be run on a wedge, a block placed on top of the back driving box, and a block also placed between the forward end of the back spring and the lower rail of the frame. The forward driver

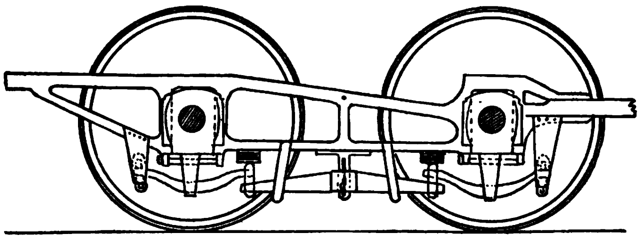


Fig. 97.

should then be run off the wedge, the back driver run on a wedge, a block placed between the back end of the forward spring and the lower rail of the frame and the block removed from the top of the front driving box. The back driver should next be run off the wedge and the front driver on a wedge, the block removed from the top of the back driving box and the front driver run down (Fig. 97).

Back Hanger of the Back Spring with Underhung Rigging. If the back hanger of the back spring of an eight-wheel underhung engine is broken, the back driver should be run on a wedge, a block placed on top of the front driving box, the back driver run off the wedge.

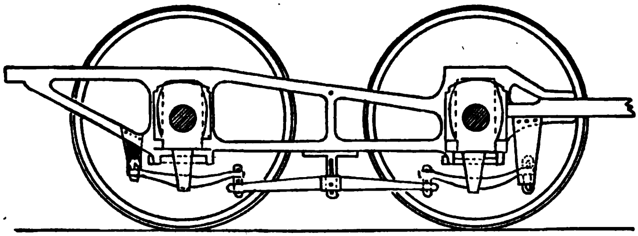


Fig. 98.

The forward driver should then be run on a wedge, a block placed between the back end of the back spring and the lower rail of the frame, and the forward driver run off the wedge. Next run the back driver on the wedge, remove the block from the front driving box, and run the back driver off the wedge. The engine is then ready to proceed (Fig. 98).

Forward Hanger of the Front Spring with Underhung Rigging. If the forward hanger of the front spring of an eight-wheel underhung engine is broken, the back driver should be run on a wedge. This raises the frame off the front driving box and permits a block to be placed on top of the front driving box and under the main frame. The back driver should then be run off the wedge and the front driver on a wedge, which will relieve the tension of the spring rigging. The front end of the front spring should then be pried down, a block placed under the lower rail of the frame and on top of

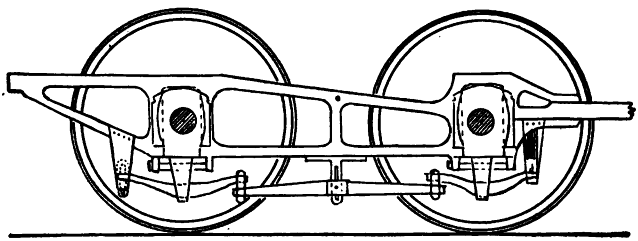


Fig. 99.

the front end of the spring, the front driver then run off the wedge and the back driver again run on a wedge, and the block removed from the front driving box. After running the back driver off the wedge the engine is then ready to proceed (Fig. 99).

BROKEN SPRING, HANGER OR EQUALIZER—TEN-WHEEL ENGINES WITH UNDER-HUNG RIGGING.

A six-wheel connected engine with an underhung spring rigging is one on which all springs and equalizers are hung under the lower rail of the frame. If the back hanger of the back spring, the front hanger of the middle spring, front hanger of the front spring, back hanger of the front spring, the front spring or the front equalizer, is broken, the back driver should be run on a wedge, an iron block placed on top of the middle driving box, the back driver run off the wedge, the middle driver run on a wedge, blocking placed solidly over the front and back driving boxes and the main driver then run off the wedge. Fig. 100 shows the frame elevated and blocks placed on top of both front and back drivers so that if any of the following parts are broken the blocks can be placed in the following manner:

Forward Hanger of the Front Spring. If the forward hanger of the forward spring is broken, a block should be placed between the forward end of the front spring and the lower rail of the frame at 1.

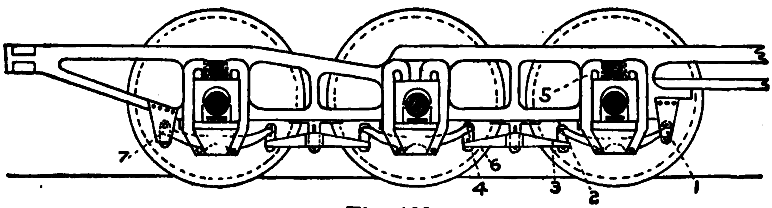


Fig. 100.

Back Hanger of the Back Spring. If the back hanger of the back spring is broken, a block should be placed between the back end of the back spring and the lower rail of the frame at 7.

Front Spring. If the front spring is broken, the forward end of the front equalizer 3 should be chained up or a block placed between the forward end of the middle spring and the lower rail of the frame at 4. In case of doubt as to whether the middle and back springs would carry the weight, a block should be placed over the front driving box 5, so that it can carry its own weight.

Front Equalizer. If the front equalizer is broken a block should be placed between the back end of the front spring 2 and the lower rail of the frame, and another block placed between the forward end of the middle spring at 4 and the lower rail of the frame.

Front Hanger of the Middle Spring. If the front hanger of the middle spring is broken, a block should be placed between the forward end of the middle spring at 4 and the lower rail of the frame and back end of the front equalizer 6 chained up, or a block placed between the back end of the front driving spring at 2 and the lower rail of the frame. On some classes of engines there is a safety hanger, and when so equipped, instead of chaining the equalizer, blocking should be placed between the safety hanger and the equalizer. The middle driver should then be run on the wedge, the blocking removed from the front and back driving boxes, the middle driver run down, and the back driver run on a wedge, and the block removed from the middle driving box. The engine is then ready to proceed.

Middle Spring. If the middle spring is broken on an engine with an underhung spring rigging, the back driver should be run on a wedge, a block placed on top of the middle driving box, the back driver run off the

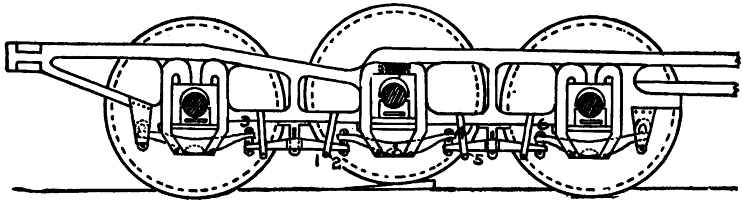


Fig. 101.

wedge, the middle driver run on a wedge and the forward end of the back equalizer 1 chained, or blocking placed between the safety hanger and the equalizer 2. If there is no safety hanger or chain, a block should be placed between the forward end of the back spring 3 and the lower rail of the frame. The back end of the forward equalizer 4 should also be chained up, or blocking placed between the safety hanger and equalizer 5, or the back end of spring 6 and the lower rail of the frame (Fig. 101), and the middle driver run off the wedge.

Back Equalizer. If the back equalizer is broken at the fulcrum of an engine with underhung spring rigging, the back driver should be run on a wedge, a block placed over the middle driving box, the back driver run off the wedge and the middle driver run on a wedge, relieving the back spring. A block should then be placed between the forward end of the back spring and the lower rail of the frame, and another block placed on top of the back driving box to assist in elevating, eliminating the necessity of running the back driver on a high wedge.

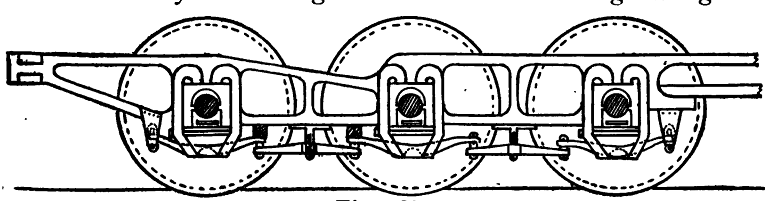


Fig. 102.

The middle driver should then be run off the wedge, the back driver run on a wedge, blocking placed between the back end of the middle spring and the lower rail of the frame, the block removed from the top of the middle driving box, the back driver run off the wedge, the middle driver run on a wedge, and the block removed from the top of the back driving box (Fig. 102). After running down the middle driver the engine is ready to proceed.

Back Spring. If the back spring is broken, the middle driver should be run on a wedge, a block placed on top of the back driving box and under the frame, the middle driver run off the wedge and the back driver run on a wedge, which relieves the weight from the spring rigging. The back end of the back equalizer should then be chained up or a block placed in the safety hanger 2, or blocking placed between the back end of

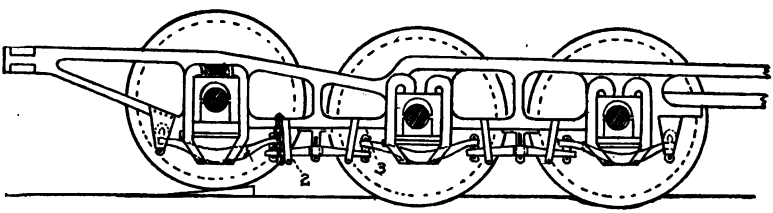


Fig. 103.

the middle spring and the lower rail of the frame at 3. Plate 103 shows the block on the back driving box with the wheel on a wedge and the equalizer chained; 2 shows where the block is placed when the engine is equipped with safety hanger; and 3 shows where blocks are placed in case there is no chain or safety hanger. The back driver should then be run off the wedge, and all loose parts removed to prevent further damage.

BROKEN SPRING, HANGER OR EQUALIZER WITH OVERHUNG RIGGING—TEN-WHEEL ENGINE.

If a front spring hanger, front spring or back hanger of front spring breaks on an engine with overhung spring rigging, and the equalizers are between the top and lower rails of the frame, the back driver should be run on a wedge, a block placed on top of the middle driving box, the back driver run down, the middle driver run on a wedge, a block placed on the front driving box and as much blocking as possible placed on the back driving box, or if the back driver has a driving box equalizer, blocking should be placed between the equalizer and the under side of the top rail of the frame. The middle driver should then be run off the wedge, relieving the spring rigging. As the engine frame is held up by the blocking placed on the driving boxes, the front end of the front equalizer can be raised with a lever and blocking placed between the equalizer and the top of the lower rail of the frame. The middle driver should then be run on a wedge, the blocking removed from the back driving box or equalizer, the middle driver run down, the back driver run on a wedge, the blocking removed from the middle driving box, the back driver run off the wedge and the blocking is finished. Fig. 104 shows the equalizer blocked up and a block placed on top of the front driving box and under the frame.

Front Equalizer. If the front equalizer is broken at the fulcrum post, and the spring or hangers are of the stirrup type, the frame should be elevated in the same manner as for a broken front spring and blocking placed in the back hanger of the front spring and the front hanger of the middle spring (Fig. 105). If this could not be done, as would be the case if a single spring

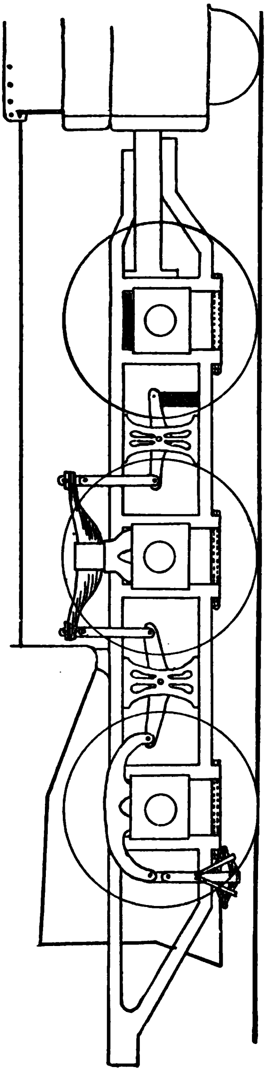


Fig. 104.

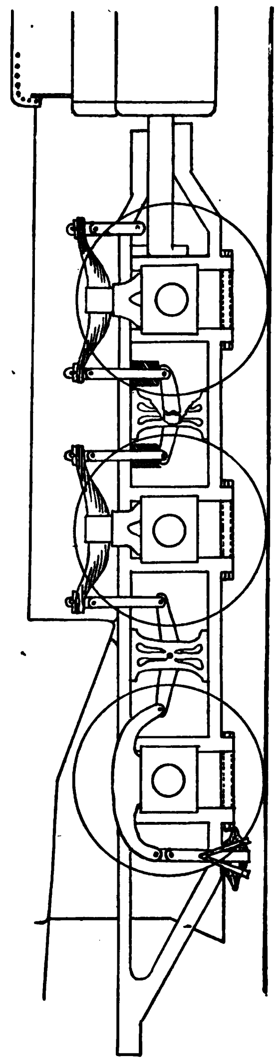


Fig. 105.

hanger were used, the back driver should be run on a wedge and a block placed on the middle driving box. The back driver should then be run off the wedge, the middle driver run on a wedge and a block placed on the front driving box to help carry the weight. The front end of the back equalizer should then be pried up and blocking placed on the top of the lower rail of the frame and underneath the front end of the equalizer, the middle driver run down, the back driver run on a wedge, the block removed from the top of the middle driving box, and the back driver run off the wedge. The engine is then ready to proceed, the weight being carried on the front driver and the back spring (Fig. 106).

Middle Spring. If the middle spring is broken the back driver should be run on a wedge, a block placed on top of the middle driving box, the back driver run down, the middle driver run on a wedge, both ends of the equalizer nearest the broken spring raised with a lever and blocking placed on top of the lower rail of the frame and under the ends of the equalizers (Fig. 107), and the middle driver run down.

Back Spring. If the back spring (or driving box equalizer, when the engine is so equipped), is broken, the middle driver should be run on a wedge, a block placed on top of the back driving box, the middle driver run down, the back driver run on a wedge, the back end of the equalizer pried up, blocking placed on top of the lower rail of the frame and under the back end of the back equalizer (Fig. 1, Plate 16), and the back driver run off the wedge. The engine is then ready to proceed.

BLOCKING ENGINES EQUIPPED WITH DRIVING BOX EQUALIZERS.

If the back spring or hanger is broken on an engine equipped with driving box equalizers, run the back driver

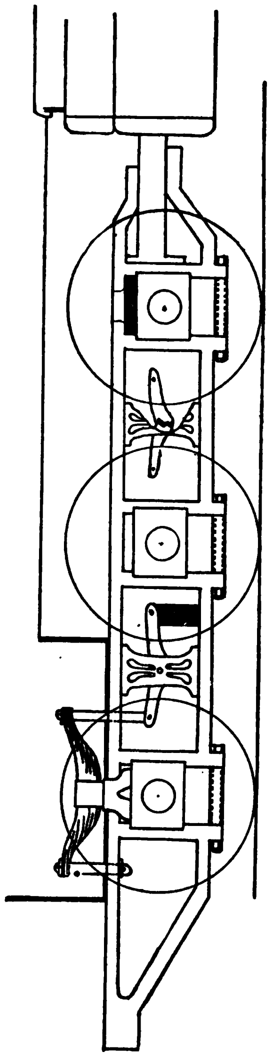


Fig. 106.

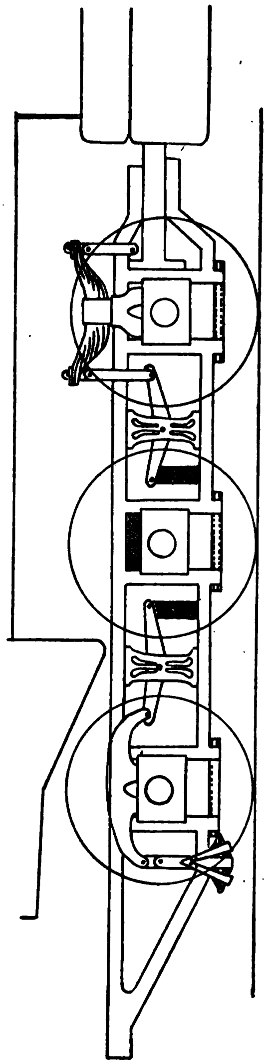


Fig. 107.

on a wedge, place a block on top of the middle driving box, run the back driver off the wedge, and run the middle driver on a wedge. This will release the spring rigging. Then place a block between the driving box equalizer, on top of the hanger, and under the rail of the frame. Next run the middle driver off the wedge, the back driver on a wedge, remove the blocking from the main driving box and run the back driver off the wedge (Fig. 2, Plate 16). The engine is then ready to proceed. If the equalizers or springs are broken on a consolidated engine, the frame should be raised and the blocking placed in the same manner.

The frame of an engine with two or more drivers hung with driving box equalizers, or with driving boxes so designed that blocks cannot be placed on their tops, can be raised and the springs blocked, if a block can be placed on top of the front driving box, by running No. 2 or 3 driver on a wedge, thus raising the frame so that a block can be placed on top of front No. 1 driving box, and then running No. 2 or 3 driver off the wedge. A fulcrum, such as the half of a tie, should then be taken, one end placed on a tie and the other end under the back end of the frame, and the engine moved, which will raise the frame and relieve the spring rigging so that any part of the spring or equalizer can be blocked. The engine should then be run off the fulcrum, and the block removed from the front driving box.

FORWARD DRIVING SPRING BROKEN ON ENGINES HAVING PONY TRUCK WITH EQUALIZER ATTACHED TO CROSS EQUALIZER.

If a front driving spring breaks on an engine having a pony truck and a long equalizer attached to the cross equalizer, the cross equalizer will drop down on the

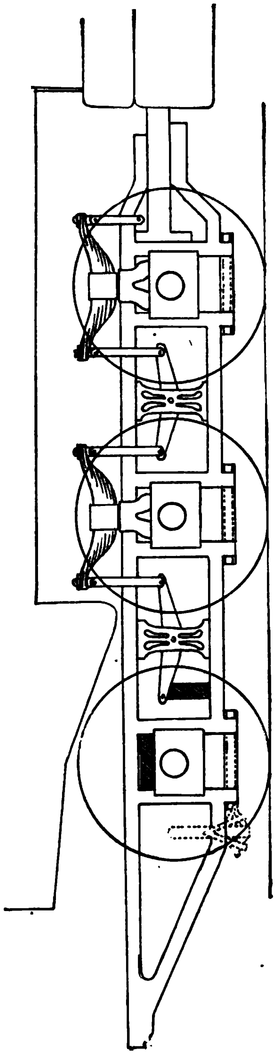


Plate 16, Fig. 1.

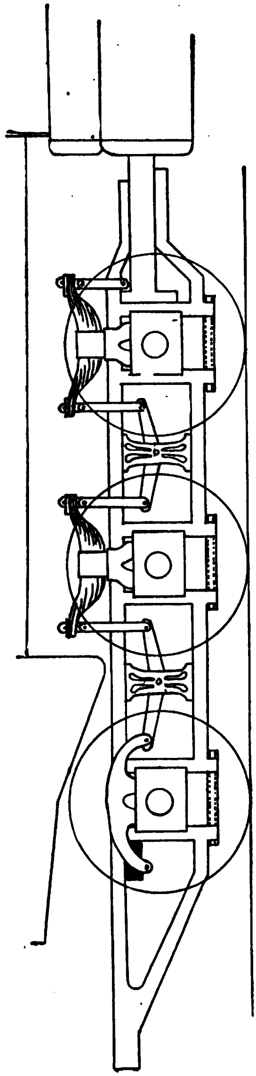


Fig. 2, Plate 16.

frame on the side on which the spring is broken. One end of a fulcrum post should be placed on a tie and the other end under the back end of the truck cqualizer, the engine moved until the equalizer is raised higher than its normal position and blocking placed between the top of the frame and the cross equalizer. If the clearance

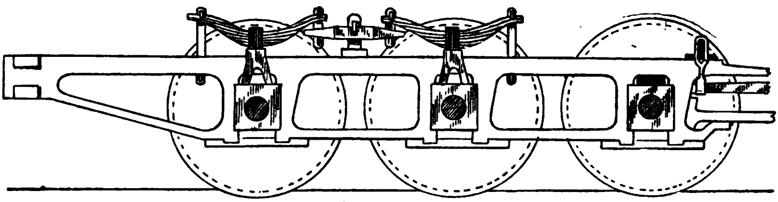


Fig. 109.

between the pilot and the top of the rail is sufficient, it will not be necessary to place a block on the front driving box. But if the pilot has settled and the clearance is insufficient, No. 2 driver should be run on a wedge, a block placed on top of No. 1 driving box (Fig 109), and No. 2 driver run down.

BROKEN SPRING, HANGER OR EQUALIZER—ATLANTIC TYPE ENGINES.

If the front spring, front hanger, or the back hanger of the front spring is broken on an Atlantic type engine having spring rigging, as shown in Fig. 110, the back driver should be run on a wedge, a block placed on top of the front driving box, another block placed on top of the trailer box and under the trailer frame, the back driver run off the wedge, one end of a fulcrum placed on a tie and the other end under the front end of the long equalizer, and the engine moved, thus raising the equalizer. If the spring is broken, a block should be placed on top of the frame and in the stirrup hanger of the back spring, or a block placed on top of the lower rail of the

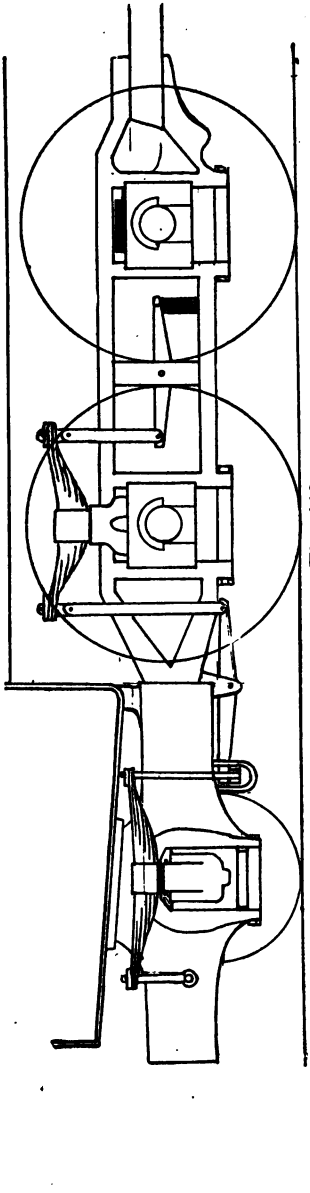


Fig. 110.

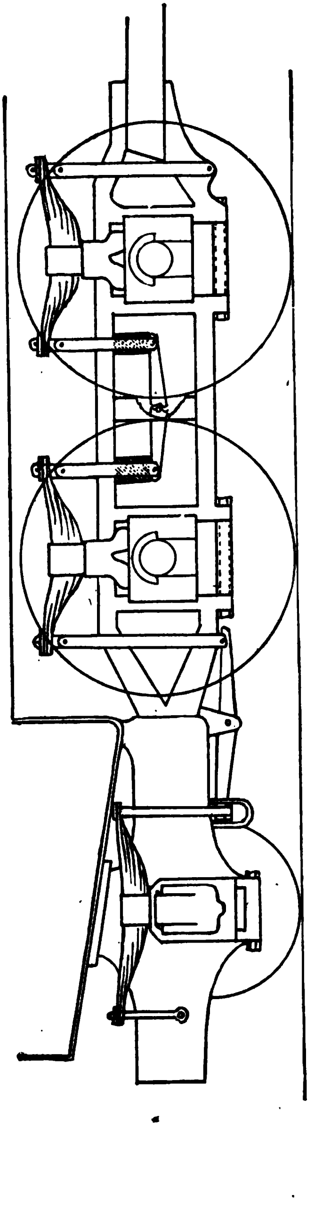


Fig. 111.

frame and under the front end of the equalizer (Fig. 110), and the back driver run on a wedge and the block removed from the trailer box.

Front Equalizer. If the front equalizer is broken the trailer should be run on a wedge, a block placed on the back driving box, the trailer run down, the back driver run on a wedge, a block placed in the stirrup of the back hanger of the front spring under the top rail of the frame, and another block placed on top of the trailer to hold the frame when the back driver is run off the wedge. If the spring rigging is not free, the forward end of the side equalizer should be staked up by means of a fulcrum and a block placed in the stirrup of the front hanger of the back driver spring and under the top rail of the frame. The back driver should then be run on a wedge, the block removed from the top of the trailer box, the back driver run down, the trailer run on a wedge, the block on top of the back driving box removed and the trailer run off the wedge. (Fig. 111.)

Back Driving Spring. If the back driving spring is broken, the trailer should be run on a wedge, a block placed on top of the back driving box, the trailer run down, the back driver run on a wedge and a block placed on top of the main frame and in the front hanger of the main spring. A block should also be placed in the back hanger of the main spring on top of the main frame (Fig. 112), and the back driver run off the wedge.

Side Equalizer. If the side equalizer is broken, the trailer should be run on a wedge, a block placed on top of the back driving box, the trailer run down, the back driver run on a wedge, a block placed on top of the cross equalizer and under the main frame and another block placed on top of the trailer box. The back driver should then be run down, the trailer run on a wedge, a block placed in the stirrup of the back hanger of the

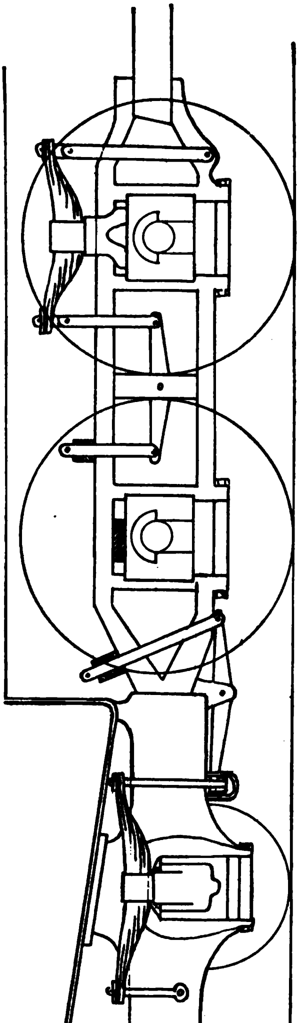


Fig. 112.

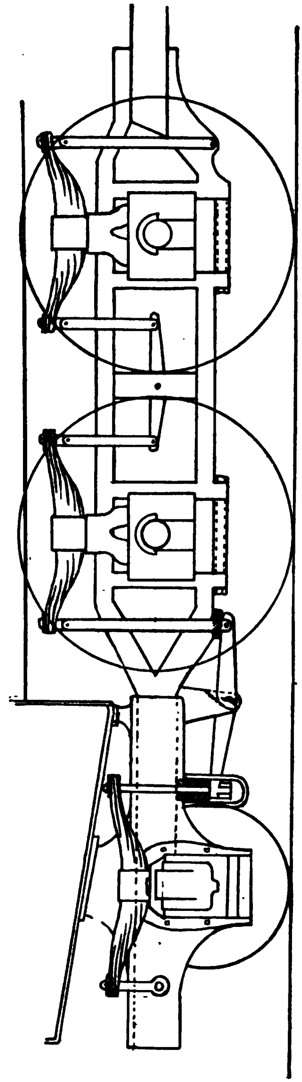


Fig. 113.

main spring under the frame, and the block on top of the back driving box removed. The trailer should then be run down, the back driver run on a wedge, the block removed from the top of the trailer box, and the back driver run off the wedge (Fig. 113).

Broken Trailer Springs on Engines Having Inside or Outside Bearings. If the trailer spring breaks on an engine of the Atlantic type, having trailer bearings inside the wheels, the back driver should be run on a wedge, a block placed on the trailer box, the back driver run off the wedge and the trailer run on a wedge. The back end of the long equalizer should then be pried up, a block placed on top of the lower rail of the frame and under the back end of the long equalizer (Fig. 114), and the trailer run off the wedge. The engine is then ready to proceed.

If the trailer spring on an Atlantic type of engine with outside trailer bearing is broken, the back driver should be run on a wedge, a block placed on the trailer box and under the supplementary frame, and the back driver run down. A fulcrum should be taken and used as a stake, one end being placed on a tie and the other end under the cross equalizer, the engine moved to raise it to position and blocking placed in the "U" hanger and under the cross equalizer (Fig. 115).

Substituting for Broken Trailer Spring or Equalizer. When substituting for a broken trailer spring, a piece of rail or tie should be used, one end of a fulcrum should be placed on a tie and the other end under the cross equalizer, and the engine moved, raising the cross equalizer up under the supplementary frame. Blocking should then be placed in the "U" hanger and under the cross equalizer, so as to hold the cross equalizer in place, and the engine moved off the fulcrum. A fulcrum should then be placed underneath the main frame back of the

trailer, and the engine moved, thus elevating the main frame. One end of the substitute should be chained to the supplementary frame and the other end to the cross

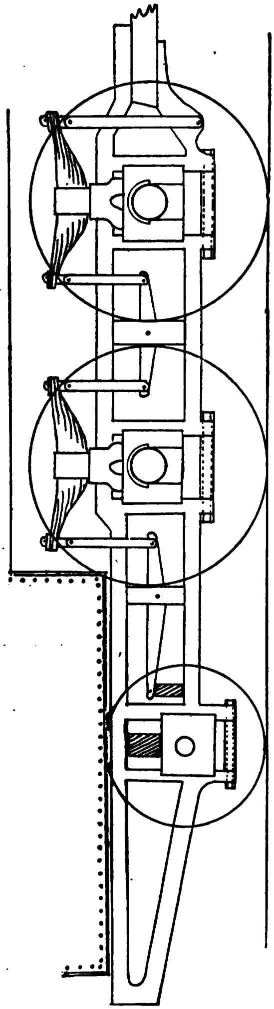


Fig. 114.

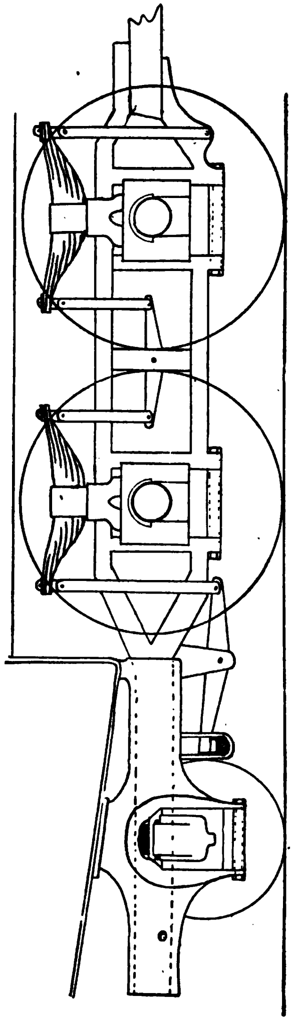


Fig. 115.

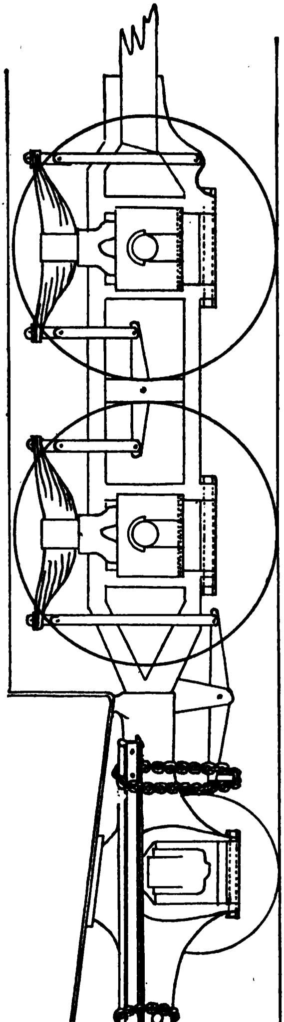


Fig. 116.

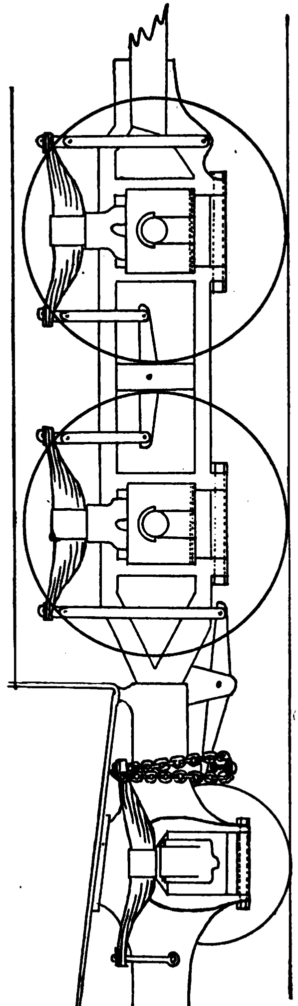


Fig. 117.

equalizer (Fig. 116), the engine run off the fulcrum, and the blocking removed from the "U" hanger.

If a cross equalizer is broken and a substitute is used, fulcrums should be placed under the back ends of both side equalizers and the engine moved so as to raise the side equalizers higher than their normal positions. A rail should then be placed in the "U" hanger and under the back end of both side equalizers and blocked up as high as possible on both sides in the hanger. The engine should then be run off the fulcrum, one end of another fulcrum placed on a tie and the other end under the main frame back of the trailer and the engine moved, thus raising the rear end of the frame so that the front end of the trailer spring can be chained up to the cross equalizer (Fig. 117). The opposite side should then be elevated and chained in the same manner, and the blocking removed from the "U" hanger under the cross equalizer.

BROKEN DRIVING AXLES.

If a front driving wheel breaks off at the axle of an eight-wheel engine, all side rods and main rod should be removed, the broken wheel also removed, or chained to the frame, the valve-stem disconnected, the valve clamped centrally on its seat and the crosshead blocked back. A fulcrum should be used to raise the axle on the broken side, blocking placed solidly between the cellar and the pedestal jaw or binder and a block placed between the spring saddle and the frame, with overhung spring rigging, or if the equalizer is between the frame, blocking should be placed between the equalizer and the lower rail of the frame. With underhung spring rigging the end of the equalizer nearest the broken axle should be chained up.

Wheels with Blind Tires. If the forward pair of wheels have blind tires, as on six or eight-wheel con-

nected engines, the opposite wheel should also be raised and blocked so that it clears the rail. In this event the engine frame should be raised by means of a fulcrum and blocking placed on top of the main boxes, but if the engine settles too low it will also be necessary to block on top of the truck equalizers and under the truck frame. If it becomes necessary to disconnect the forward pair of springs on a Mogul engine, a truck brass should be placed between the long equalizer and the truck axle. If the engine should slip with the main rods up, and could not handle itself, it would be necessary to obtain assistance to get the engine moved on to a block, so that a block could be placed on the main driving box, to throw more weight on the main driver, and so prevent the engine from slipping. The driver brake should be cut out in all cases. The fulcrum should then be removed and if the frame settles too much it should be elevated and blocking placed on the driving boxes nearest the main wheel on the broken side. If it is an eight-wheel engine and the pilot fails to clear the rail, the fulcrum should be placed under the pilot beam, the frame raised and blocking placed between the equalizer and the engine truck frame to keep the pilot a safe distance above the rails.

Main Wheel. If the main wheel breaks off at the axle, the engine should be disconnected on the broken side, the valve clamped centrally on its seat, the cross-head blocked, and all side rods and the broken wheel removed. The eccentrics will prevent the other wheel from leaving the rail, even if it has a blind tire. A fulcrum should be used to raise the axle on the broken side and blocking placed between the pedestal jaws and the cellar. If the engine has an overhung spring rigging, blocking should be placed between the spring saddle and the frame. If the equalizer is between the rails of the

frame, blocking should be placed between the equalizers and the lower rail of the frame, but with underhung spring rigging it would be necessary to chain up the equalizers on both sides of the main driver. If the back wheel is broken it should be blocked in the same manner as for a broken back tire.

LEAKS AND BLOWS.

If an engine blows badly and is unable to start the train when on the right-hand center, the blow will generally be on the left side, as the opposite engine is the only power the engine has to move the second engine off the center.

Blows on an engine may be caused by cut valve-seats or pistons, broken balance strips, stuck-down or broken springs under the strips, balance plates which have too great a clearance above the valve, broken or worn packing rings in piston valves, broken or worn cylinder packing rings, or two or more rings which have turned so that their openings come opposite to one another at the top of the piston, broken valve-seats or valves, a blow from under a false valve-seat, or a broken or stuck-open by-pass valve.

A valve blow is a continuous blow, and has a wheezing sound. A valve strip blow is also continuous and sounds like a blower that is partly open. The cylinder packing blow is the strongest at the beginning of the stroke and diminishes as the piston travels toward the end of its stroke.

Locating Valve Blows. To ascertain on which side a blow occurs, place the engine on the quarter, plumb the rocker arm, open the cylinder cock, then open the throttle slightly and admit steam to the steam-chest. If steam shows at the cylinder cock and there is a blow at the stack it would indicate a blow on that side. If

no steam appears at the cylinder cock, the opposite side should be tested in the same manner.

In testing for a broken valve strip, place the engine in the same position, plumb the rocker arm, give the engine steam and open the channel drain cocks in the exhaust cavity. If the steam shows it will indicate that the strip is blowing on that side. If the engine has no channel cock, the reverse lever should be moved from the forward to the back motion, and the engine placed on the quarter on the opposite side, after which the reverse lever should be moved from the forward to the back motion in the same manner. The side on which the reverse lever moves the hardest will be the one on which the strip is blowing.

Locating Defective Cylinder Packing. To locate the side on which the cylinder packing is blowing, the engine should be placed on the quarter on the right side, with the reverse lever in the full forward or backward gear. The cylinder cock should then be opened on the opposite end to the one at which steam is being admitted. If steam shows at that cylinder cock and at the stack, it will indicate a broken or badly worn cylinder packing on that side. If the blow is not located on the right side, it should be tested for in the same manner on the left side.

Defective Rings—Piston Valves. A broken admission ring on the piston valve admits steam too early, and cuts it off too late, producing a loud exhaust followed by a blow.

When an exhaust ring on a piston valve is broken there will be a blow at the stack when steam is first admitted to the cylinder, which will continue until the admission ring covers the port. When the valve returns there will be another blow and also a light and early exhaust.

To distinguish between a broken by-pass valve and a

broken admission ring, the valve should be placed centrally upon its seat, the cylinder cocks opened and steam admitted to the valve. If steam appears at the cylinder cock it will indicate that the by-pass valve or admission ring is broken. The main valve should be moved to cut off the admission of steam to the cylinder. If the steam is not cut off until the exhaust ring of the valve covers the admission bridge, it is an indication that the admission ring is broken, but if steam still appears at the cylinder cock and there is a heavy blow at the stack, it is the by-pass valve which is broken.

This test applies to inside admission piston valves. The valve should be moved in the opposite direction when testing outside admission piston valves.

ECCENTRICS.

Throw of the Eccentric. To find the throw of an eccentric, the greatest distance from the axle or bore at E (Fig. 73) to the outside face of the eccentric at D should be measured. Next, the least distance from the axle at F to the outside face at G should be measured. By the outside face is meant the bearing on which the eccentric strap fits. The difference between the two distances will be the throw of the eccentric. It can also be determined by the difference in distance between the center of the axle and the center of the eccentric, which represents one-half of the throw.

Distinguishing Between Go-Ahead and Back-Up Eccentrics. In distinguishing between the go-ahead and the back-up eccentric, it should be remembered that the go-ahead eccentric strap 11 and blade 12 (Fig. 49) are always connected at the top with a link 9 and the back-up blade 12 is connected to the bottom of the link.

Positions of Eccentric on the Journal. The position of an eccentric on the axle relative to the crank pin varies

with inside and ouside admission valves. With inside admission, direct motion, the eccentrics are placed 90 degrees minus lap and lead, in an angle towards the pin (Fig. 2, Plate 11), while with an outside admission the eccentrics are placed 90 degrees plus the lap and lead, in an angle from the pin (Fig. 1, Plate 11).

With an outside admission, indirect valve motion, the eccentrics are placed 90 degrees minus lap and lead, in an angle toward the pin (Fig. 2, Plate 11), and with an indirect motion, inside admission, the eccentrics are placed 90 degrees plus the lap and lead, in an angle from the pin (Fig. 1, Plate 11).

Slipping of Eccentrics. If an eccentric has slipped on the axle it can be detected by the relative position of the eccentric on the shaft to the pin, or by placing the reverse lever in the full forward motion, opening the cylinder cocks, moving the engine along slowly, watching the crosshead and noting when the steam appears at the cylinder cock, whether it is early or late in the stroke. If steam appears at the proper time it will show that the go-ahead eccentric has not slipped.

To test for the back-up eccentric the reverse lever should be placed in the full backward motion, and the test proceeded with in the same manner as with the go-ahead eccentric.

A slipped eccentric can also be detected by the keyway on the shaft. With an inside direct or an outside indirect motion engine in the forward motion, the go-ahead eccentric will slip away from the pin and the back-up eccentric will slip toward the pin, while with an outside admission, direct, and an inside admission, indirect motion, with the engine in the forward motion, the go-ahead eccentric will slip toward, and the back-up eccentric away from the pin.

An eccentric which has slipped in this manner

causes a late admission of steam to the cylinder, if it be a go-ahead eccentric. A slipped back-up eccentric will cause a too early admission of steam to the cylinder with either motion.

When the engine is backing up the eccentric will slip in the direction opposite to that when the engine is moving ahead.

If an eccentric which is held in place by keys slips turn the eccentric on the shaft until the grooves in the eccentric and the shaft register, and then replace the key and tighten set-screw B (Fig. 73).

If the eccentric is not keyed, place the engine on either center on the side on which the eccentric has slipped, put the reverse lever in full forward gear for the go-ahead eccentric and in full back gear for the back-up eccentric, set the brake and block the wheels securely, and then have the fireman open the throttle slightly and open the cylinder cocks. The slipped eccentric should then be moved either toward or away from the pin, according to the motion of the engine, until steam appears at the cylinder cock at the end of the cylinder in which the piston lies. The eccentric should then be secured.

When setting an eccentric the engineman should place the engine on that center which will enable him most easily to get at the set-screws and eccentric.

The usual causes of eccentrics or blades slipping are loose set-screws, hot eccentrics, tightening up set-screws when the bolts holding the parts of the eccentric together are loose, or too much strain on the eccentric when moving the valve gear.

Causes of Engine Going "Lame." When an engine suddenly goes "lame" (a term commonly used when the exhausts are uneven), it may be due to a slipped eccentric or blade, loose strap bolts, sprung blade, sprung tumbling shaft, loose rocker box, sprung stem or cracked

valve yoke, or to any part of the valve or its seat being broken.

ECCENTRIC BLADES.

Eccentric blades are made adjustable in order to permit adjustment of the valve travel, so that an even admission of steam can be had at both steam ports.

If one of the blades is too long or too short, it will cause too early an admission of steam and a late cut-off and exhaust in one end of the cylinder, and in the opposite end a late admission and too early cut-off and exhaust.

If an eccentric blade slips the engine should be placed on the center on the side on which the blade has slipped, and, if it is the go-ahead blade which has slipped, the reverse lever should be placed in the full forward gear. If it is the back-up blade which has slipped, the reverse lever should be placed in the full backward gear, the brake set, the wheels blocked, the cylinder cocks opened, and the blade moved until steam just appears at the cylinder cock at the end of the cylinder in which the piston rests. The blade should then be secured to the strap by tightening of the bolts.

LOCOMOTIVE ENGINEERING.

REVERSING THE MOTION OF THE ENGINE.

Moving the reverse lever from one end of the quadrant to the other reverses the motion of the engine. When the reverse lever is in the forward gear, the link is below the center line of motion, and the go-ahead eccentric controls the engine (Fig. 49), while with the lever in the back gear the link is raised above the center line of motion and the back-up eccentrics are in control.

BLOCKING THE CROSSHEADS.

When it is necessary to block a crosshead it should be blocked at the rear end of the guide if possible, guarding against getting the cylinder packing rings into the counterbore. With engines having forward drivers opposite the guides, the crosshead must be blocked full ahead or in the center of the guide in order to prevent the forward crank pin from striking the wrist pin or crosshead.

PISTON AND VALVE-STEM PACKING.

Metallic packing rings on a valve-stem or a piston rod are usually held in place by a spiral spring pressing against a ring and forcing the packing into a bell-shaped cone. Suitable provision is made for the uneven movement of the rod, as the cone holding the packing has a ground and steam-tight joint which permits it to have a lateral motion against the face of the packing gland. The packing gland is bolted to the steam-chest and the piston rod gland is bolted to the stuffing-box on the back head, holding the spring, packing and rings in their positions. The gland also forms a steam-tight joint between the gland and stuffing-box.

MAIN THROTTLE PACKING.

If the packing blows out of the main throttle stuffing-box, and the stuffing-box is high, so that the water can be kept below it, tighten up on the gland securely and proceed. But if the stuffing-box is low, it would not be safe to run the engine with water below it. In that case proceed to the nearest siding, fill the boiler with water, so reducing the steam pressure, and repack the stuffing-box with candle wicking, bell cord or any other material which will serve to stop the flow of steam and water.

LEAKY THROTTLE VALVE OR DRY PIPE.

If the throttle is closed and steam escapes from the cylinder cocks it may be due to a leaky dry pipe, a leaky throttle valve, or the steam may come from the lubricator.

To distinguish between a leaky throttle valve and a leaky dry pipe, the lubricator should be shut off and the boiler filled sufficiently to submerge the dry pipe. If dry steam appears at the cylinder cocks with the throttle shut, it indicates a leaky throttle valve. If both steam and water appear at the cylinder cocks it indicates a leaky dry pipe.

LEAKY STEAM PIPES.

Leaky steam pipes interfere with the draft of the fire and cause the engine to steam poorly. To test for leaky steam pipes, the reverse lever should be placed on the center, the brake set and the throttle opened, giving the engine a full head of steam. Then open the front end door and apply a lighted torch to the steam joints in the front end. The proper test for leaky steam pipes is the hydraulic test made at the shops.

LEAKY EXHAUST OR NOZZLE JOINTS.

Leaky exhaust pipe joints or leaky nozzle joints can be tested for by placing the lever forward or back, moving the engine slowly with the brake set so that a full head of steam

can be used, opening the front end door and watching the joints. Cinders never accumulate around such leaks, but are always driven away.

DISABLED ENGINE.

When an engine becomes disabled on the road, the train should first be protected in both front and rear, if necessary, by a flagman. Such temporary repairs should then be made as are necessary to enable the train to reach the next siding without blocking main line. After reaching the siding all necessary repairs that the material and tools on hand will permit should be made. If the breakdown is of such a nature that it is impossible to make even temporary repairs and clear the main track, a message giving full particulars and asking for assistance should be sent to the nearest open telegraph office and the engine be prepared to be towed in.

WASHOUT PLUG BLOWING OUT, OR BLOW-OFF COCK FAILING TO CLOSE.

If a washout plug blows out or a blow-off cock will not close, the boiler should be protected by drawing or deadening the fire. If the trouble occurs in freezing weather all parts containing water should be drained. These parts would include the delivery pipe, branch pipe, steam-heat and dynamo lines, the blower and the pipes leading to the pump, steam-gauge and lubricator. The tank hose also should be uncoupled between the tank and engine. If any water remains in the leg of the boiler it should be drained. Care should be taken when draining the tank not to wash away gravel from the road bed, or flood the switches so that they would freeze up. If the trouble occurs in warm weather, the blow-off cock should be taken apart and repaired, if possible to do so, and then replaced. If the washout plug blows out, plug it with a suitable plug and prepare to refill the boiler.

REFILLING THE BOILER.

The boiler can be refilled while being towed in the following manner: All outward openings to the boiler, such as the steam-heat line, dynamo line, blower and air-pump should be closed, the lubricator and steam-gauge cock shut off, the heater valve screwed down, the main throttle on the injector opened, the reverse lever placed in the direction in which the engine is being towed, and the main throttle opened, the tank valve open, and a good supply of air admitted to the tank. All openings outside the cab, such as the cylinder cocks, relief valves, blow-off cocks, and whistle valve, must be closed (and by-pass valves, if on a piston-valved engine), and the engine must be towed sufficiently fast for the movement of the pistons in the cylinders to create a vacuum in the boiler and thus draw the water from the tank to the boiler.

LEAKING OR BURSTED FLUES.

If a flue leaks badly it should be plugged in the fire-box, and if a flue bursts it should be plugged in the fire-box and front end. In most cases an engine with a bursted flue must be towed in.

WHISTLE OR SAFETY VALVE BLOWING OUT.

If a whistle or safety-valve blows out, both injectors should be put to work at once, in order to secure a full supply of water, so that when the pressure is reduced and the injectors stop working, there will be sufficient water in the boiler to permit the necessary repairs to be made and the fire rebuilt. A tightly fitting plug should then be whittled from a long piece of dry pine wood and driven down in place of the whistle or safety-valve. About fourteen inches of this plug should extend into the dome. A piece of board or plank should then be used as a lever and tied to the hand railing to hold the plug in place. A dry pine plug should

always be used, as steam will cause the plug to swell and assist in holding it in place.

ENGINE THROWING FIRE.

When an engine throws fire out of the stack it may be caused by a burned out netting, a hole in the netting, a loose manhole, or fine slack coal. To prevent this, avoid slipping and work the engine as lightly as possible. If the engine is setting fires along the right of way, proceed to the next siding, open the front end door and remedy the defect if possible. If the trouble cannot be overcome with the means at hand, the superintendent should be notified, and the engineman will be governed by his instructions.

DERAILED ENGINE.

An engine which has been off the track and has been derailed should be carefully inspected to see that there are no broken driving box cellars, bent or sprung rods or crank pins, broken brake rigging, loose tires, loose wheels, broken drawbar castings or drawbars, sprung axles or journals.

RAISING WHEELS.

When it is necessary to raise a wheel and jacks are not available, or the engine is too heavy to be raised with ordinary jacks, it can be done by running the wheel up on frogs or wedges, or by elevating the frame by means of a fulcrum and levers.

DRIVING BOX HANGERS UNHOOKED.

If an engine has been off the track and the driving box hangers have become unhooked from the driving box, which frequently occurs with underhung spring rigging, they can be replaced in position by taking a tie or a frog and building up under one end of it, so that it will rest in an inclined position under the spring socket, moving the engine and skidding

the spring socket up sufficiently for the hangers to be replaced. All four hangers should then be tied securely with a piece of bell cord in order to keep them in place while sliding the spring socket off the frog or tie.

REVERSING THE ENGINE AT HIGH SPEED.

If the engine is reversed at high speed, the throttle should be opened, allowing the compression to pass into the boiler and be relieved at the safety-valve.

EXTENSION PISTON RODS.

When piston rods are extended through the front cylinder head, the purpose is to better support the piston, and to produce a uniform wear on the cylinder. This type of piston is especially desirable with large cylinders.

TAKING DOWN MAIN ROD.

When a main rod is taken down, and there is no collar between the main and the side rod, the side rod can be held in place on the pin by a wooden or metal collar clamped on the outer end of the pin. If there is no collar on hand, small pieces of wood can be sawed to fit lengthwise and tied securely around the pin with the bell cord or wire. The two sections of the main rod brass can be used and fastened in place in the same manner.

REMOVING ENGINE AND TENDER TRUCK BRASSES.

An engine truck brass can be removed and replaced by a new one while on the road, by removing the oil pipe (if so equipped) and cellar, placing one end of a fulcrum of proper length on a tie and the other end under the corner of the engine truck box, or a nut or suitable blocking between the binder brace and the truck box, then placing a fulcrum on the corner of the truck frame, and moving the

engine ahead or back. This will raise the truck box so that the old brass can be taken out and replaced with a new one. The engine should then be run off the fulcrum, the oil pipe and cellar replaced.

If a tender truck brass needs replacing with a new one while on the road, the packing should be taken out, one end of a fulcrum of suitable length placed on a tie and the other end placed under the tender truck box. Anotner fulcrum two inches shorter than the first should be placed on the opposite side under the tender truck box on the same pair of wheels, for the purpose of keeping the wheel on which the box is raised down to the rail. The engine should then be moved enough to raise the box, the old brass taken out and replaced with a new one, the box lowered by again moving the engine, and the box repacked.

An outside trailer brass can be replaced in the same manner.

With an inside trailer bearing it would be necessary to proceed in the same manner as for removing and replacing engine truck brasses.

CYLINDERS LOOSE IN THE FRAME.

Cylinders are fastened to the frame by means of cylinder bolts and keys. If a key works loose, it should be driven in securely. If a key is lost, it should be replaced with a piece of iron, such as a rod key or a railroad spike. If it is impossible to replace the key, the valve should be disconnected and clamped centrally on its seat, and the engine should proceed on one side, in order to prevent further damage.

DRIVING BOXES AND SPRINGS.

The driving boxes are not secured rigidly to the frame, but can move up and down, thus permitting the wheels to conform to the inequalities of the track. They are rigidly

held against any forward and backward motion by the shoes and wedges bearing against the frame. The driving boxes support the springs, the ends of which are fastened to the frame directly or through equalizers which will always maintain the same weight on each driving box, even when one wheel strikes a high or a low spot in the track. They cause an engine to ride more easily, and the springs, spring hangers and equalizers are for the purpose of holding the frame a certain height from the top of the driving box. If any one of the springs, hangers or equalizers is broken, it will allow the frame to drop on the driving box, and if the frame were not blocked up, it would cause the driving boxes to heat, or possibly to break, and would also cause a hard riding engine.

ELEVATING WHEELS AND FRAMES.

A driving wheel is run on wedges for the purpose of elevating the frame ahead or back of the wheel which is on the wedge, permitting the placing of a block between the top of the driving box and the frame, in order to elevate the frame further. This enables the driver, the driving box of which has been so blocked, to carry its proportion of the weight, and the frame on that side is held at the proper level with the frame on the opposite side.

The blocking used on top of driving boxes with heavy power must be of iron. Care should be taken when running a wheel on wedges that good material is used. If a wheel is raised with the frame and it slips off the wedge, it is liable to break either the frame or driving boxes and possibly derail the wheels. Driving boxes that are blocked must be well oiled and run slow to prevent heating.

INSPECTION.

An engineman should always inspect his engine thoroughly for possible defects before attaching it to a train. He should know the condition of the fire-box, grates and

ash pan; that the gauge and water-glass cocks are open and working freely; that there is a sufficient supply of water in the boiler; examine the condition of the engineer's brake-valve and air-pump and test the brakes to see that they apply and release properly, noting that they have the proper piston travel. Also note that the steam-heat reducing valve regulates the pressure properly; see that there is a sufficient supply of oil and grease; that the sand-box is filled; that the sander is working properly, and take such other precautions as may be necessary to prevent an engine failure.

Before starting on a trip an engine should be provided with the necessary tools for making repairs in case of a breakdown. The list of tools should include a pinch-bar, pair of jacks, four oak wedges, the necessary blocking for crosshead, ax and saw, an extra rod key (when the engine is not equipped with solid rods), valve-stem clamp and the necessary firing tools. All flagging and signal supplies are classed as tools.

When repairs have been made or work done on valves, brasses, etc., the engineman should make a thorough inspection of them before starting on the trip to see that the work has been properly done, and that all movable parts have been returned to their places and properly connected up.

GUIDES AND CROSSHEADS.

When the guides and crossheads are not in line there is danger of heating and cutting the guides, breaking off the guide lugs on back cylinder heads, wearing out the walls of the cylinder and heating the main rod brasses.

Crossheads and guides should be reported closed when there is sufficient lost motion between the crosshead and guides to cause a pound when the pin is leaving either center and the crosshead is beginning the return stroke.

LOST MOTION BETWEEN ENGINE AND TENDER.

Lost motion between the engine and tender should be taken up when it is sufficient to cause a strain on the draw-bar by the backward and forward lurch of the engine while in motion, or a forward lurch in starting.

STARTING THE ENGINE.

An engine should always be started with the reverse lever in full gear in either direction. A gradual admission of steam to the cylinders should be made, the cylinder cocks should be open if permissible, slowly starting one car after another until the entire train has been started.

WORKING STEAM EXPANSIVELY.

After a locomotive has the train under headway it can be run more economically by working the steam expansively, when conditions will permit, by hooking up the reverse lever one notch at a time to a point where the engine will handle the train and make the required time with a full or a nearly full throttle. On some types of high pressure engines, however, the best results are produced by working the engine at a longer stroke and less throttle.

Working steam expansively is the process by which steam is admitted into the cylinder, and the admission port closed by the valve cutting off the boiler pressure from the cylinder before the piston has traveled its full stroke, which allows the expansive force of the steam to exert its energy upon the piston from the time the cut-off takes place up to the point of its release through the exhaust port.

POUNDS AND THEIR CAUSES.

The pounding of an engine while working steam is caused by wedges which are improperly adjusted, lost motion between the crosshead and guides, hot driving boxes, broken

driving boxes, loose brasses in driving boxes, improper keying of the rod brasses, flat spots in a tire, a piston rod which has become loose in the crosshead, or a piston becoming loose on the piston rod. When steam is shut off the pound may be caused by flat spots in a tire, follower bolts becoming loose, the follower bolt head dropping into the cylinder, or main rods being too long or too short.

A pound in driving boxes, wedges or rod brasses can be located by placing the right main pin on the top quarter, giving the cylinder a little steam and reversing the lever under pressure. If the pound is not located on the right side, the test should be repeated in the same manner on the left side.

REPORTING WORK ON WHEELS AND TRUCKS.

When reporting work to be done on any wheel or truck of the engine or tank, the part must be designated by number. Beginning with the first wheel behind the pilot, which is No. 1, and following to the rear wheel of the tank, omitting the drivers, they should be designated in their numerical order, and the letters "R" (right) and "L" (left) used to indicate the side of the engine on which they are located.

On a four-wheel connected engine the drivers should be designated as "right front" and "right back" or "left front" and "left back." The drivers on a six-wheel engine would be "right front," "right middle" and "right back." On the left side the drivers should be named in the same manner except that the word "left" would be substituted for "right." On a consolidated engine they would be "Right Nos. 1, 2, 3 and 4—" and "Left Nos. 1, 2, 3 and 4 drivers," No. 1 being the forward driver.

WHEEL BASE.

The rigid wheel base of an engine is the distance between the centers of the front and back pairs of driving wheels.

The total wheel base of an engine is the distance from the center of the forward engine truck wheel to that of the back wheel of the engine.

DEFECTIVE WHEELS.

Flat or shelled-out parts in a wheel, or sharp flanges would constitute a bad wheel, the condemning of the wheel to be governed by an M. C. B. (Master Car Builders') standard gauge.

USE OF THE SANDER.

When using the sander the sand from both feed pipes should strike the rail in order to prevent an unequal strain on the engine and uneven wear of the tires.

ABUSE OF AN ENGINE.

The abuse of an engine consists of unnecessary slipping of the drivers, improper care, working steam at a longer point of cut-off than is necessary, over-pumping the water supply in the boiler, poor firing, the clogging of one sand pipe, or sand from one pipe only striking the rail and failure to report the necessary work which should be done to keep the engine in good repair.

MOVING ENGINE OFF THE CENTER.

When an engine is disabled on one side, and the main rod and piston are left up, and the working engine stops on the center, it can be started by moving the valve on the disabled side by hand sufficiently to admit enough steam to move the engine off the center, after which the valve should be placed in its former position and clamped.

COMPOUND LOCOMOTIVES.

Owing to the large number of publications and text books, which are devoted exclusively to treatises on the Compound Locomotive, this text will treat the subject only briefly, on the parts that are most common in this class of engines. However; there is a great diversity of opinion regarding the merits of compound locomotives, although they have been in use for many years. While they have given excellent results in some cases on many roads where they have been given a trial, the additional expense for repairs has largely offset their economy of fuel, and their use has been discontinued. While the compound locomotive has many disadvantages under the present mode of construction, it embodies the correct principle of economy and will, no doubt, when improved become the established type of American locomotive. There are several different types of compounds in use, the cross compound, the tandem and the Vauclain being the principal forms used. On one side the cross or two-cylinder compound has a high pressure, and on the opposite side a low pressure cylinder. The cylinders in this system of compounding are made of different diameters in order to equalize the power on each side of the engine. The tandem compound is a four-cylinder engine with a high and low pressure cylinder on each side. The Vauclain compound is also a four-cylinder engine with two cylinders, one high and one low pressure, on each side of the engine.

The same valve gear is used upon compound locomotives as upon the simple engines. The compound type cannot handle a heavier tonnage than can be handled at a given speed with a simple engine of similar weight and class. No locomotive can haul more than its tractive power will allow, but the compound will, at low speed on heavy grades, keep a train in motion where a single expansion locomotive

will stall. This is due to the fact that the pressure on the crank pins of the compound is more uniform throughout the stroke than is the case with a single expansion engine.

One of the advantages of the compound locomotive is, that owing to the more economical use of steam, less demand is made upon the boiler. Sufficient steam pressure is maintained with a mild exhaust, due to the low pressure of the steam when exhausted from the cylinders. The exhaust does not carry unconsumed fuel through the flues into the smoke-box and thence out of the smokestack, but is sufficiently strong to maintain the necessary draft for combustion.

The use of the compound principle enables the locomotive to develop its full efficiency under conditions which, with a simple engine, would require a boiler so large as to be out of the question under the conditions governing locomotive construction.

The heating surfaces of a boiler absorb heat units from the fire and deliver them to the water at a certain rate. If the rate at which the products of combustion are carried away exceeds the rate of absorption, there will be a continual waste that can only be overcome by reducing the velocity with which the products of combustion are carried away. In the compound locomotive this is effected by the milder exhaust. The milder exhaust is the result of a lower back pressure, which permits a greater effective power on the piston.

The economical use of steam results in the saving of water and fuel. In bad water districts it reduces the frequency of boiler washing and results in greater life and diminished repairs to boiler and flues.

Compounds as a rule do not drift as easily as a high pressure engine, because of their additional reciprocating parts. When steam is shut off in running down grade the piston acts as an air compressor, causing thumping, rough

riding and cooling of the cylinder, as well as a strong draft in the stack at a time when no steam and little draft are required, thus causing a waste of fuel. The economy of compounds is considerably reduced at such times.

A compound engine differs from a simple engine in that it works steam double expansion, first in the high pressure and then in the low pressure cylinder.

The high pressure cylinder is so called for the reason that it takes its steam direct from the boiler at nearly boiler pressure, while the low pressure cylinder, under ordinary conditions, receives the steam from the high pressure cylinder at a greatly reduced pressure.

The advantages of the compound over the single expansion engine are that there is a lighter consumption of fuel and water, it does not require as high a steam pressure, a greater expansion of steam is obtained, and it can be operated so that its power can be increased.

SCHENECTADY TWO-CYLINDER TYPE COMPOUND.

This type of compound can be operated as a simple engine by turning the handle of the three-way cock in the cab, which is moved by hand to admit air or steam into the pipe, which connects with one end of separate exhaust valve chamber A (Fig. 118), forcing the separate exhaust valve from right to left against the tension of the spring S. When the throttle is open steam is admitted to passage E leading to the intercepting valve, forcing the valve from left to right and permitting the steam to pass through the valve and ports G from which it passes through the reducing valve to the low pressure steam-chest. Steam is also admitted directly from the steam-pipe to the high pressure cylinder. The steam in the high pressure cylinder exhausts through the receiver and separate exhaust passage, while

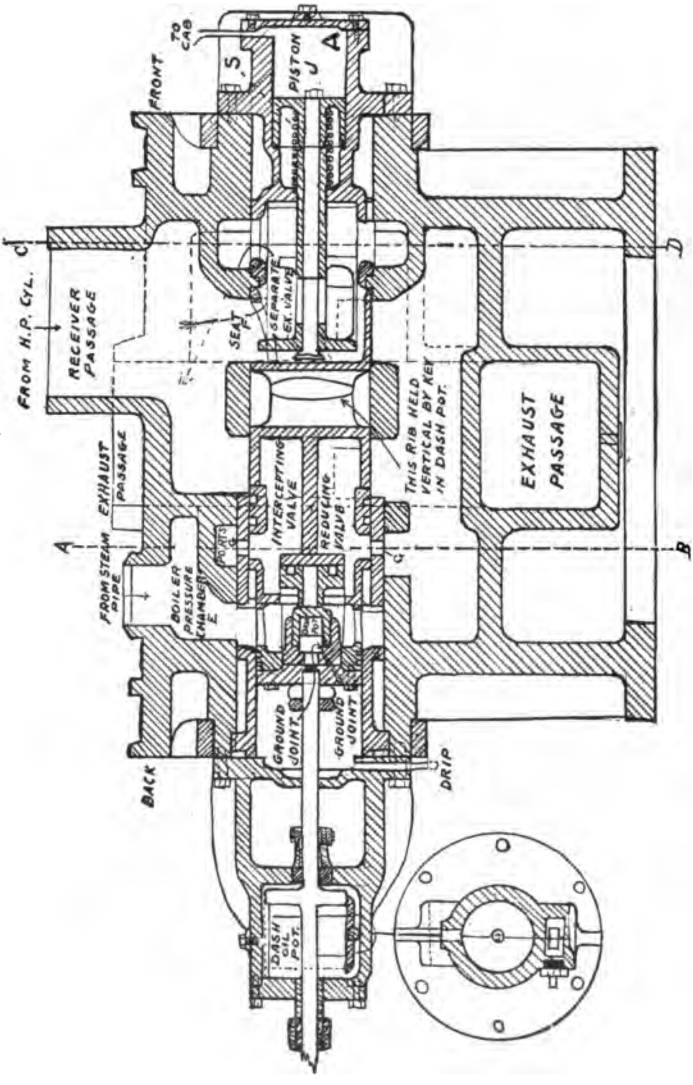

TO CAB
FRONT
PISTON
J
A
S
C
FROM H.P. CYL.
RECEIVER PASSAGE
SEAT
SEPARATE EX. VALVE
D
EXHAUST PASSAGE
THIS RIB HELD VERTICAL BY KEY IN DASH POT.
EXHAUST PASSAGE
INTERCEPTING VALVE
REDUCING VALVE
A
B
G
FROM STEAM PIPE
BOILER PRESSURE CHAMBER E
GROUND JOINT
GROUND JOINT
BACK
DRIP
DASH OIL POT.

Fig. 118.

the steam in the low pressure cylinder exhausts in the same manner as when working in compound position. Figs. 118 and 119 are self-explanatory, showing clearly the travel of the steam when working as a simple or as a compound engine.

The purpose of the oil dashpot is to insure a steady movement of the valve without shock. The dashpot should be kept full of engine oil, which will assist the intercepting valve in maintaining a steady movement. If there is no oil in the dashpot it will allow the intercepting valve to slam, this being the usual cause of the valve breaking.

The two-cylinder compound is changed from simple to compound by returning the three-way cock to its normal position, which will permit the pressure to be withdrawn from the piston head of the separate exhaust valve. This allows the compressed spring to force the separate exhaust valve to its normal position, closing the communication between the high pressure cylinder and the exhaust (Fig. 119). The pressure in the receiver due to the exhaust from the high pressure cylinder will force the intercepting valve to the left, which opens a passage for the exhaust steam through the receiver to the low pressure steam-chest. A movement of the intercepting valve to the left prevents the passage of live steam from the boiler to the low pressure steam-chest.

The intercepting and reducing valves of a two-cylinder compound engine are automatically operated by the steam pressure exerted upon them, this being due to the difference in the areas of the ends of the valves.

A compound engine should be operated as a simple engine only when starting a heavy train or to prevent the engine from stalling on a grade, and this should be done at a low speed, not to exceed four to six miles per hour.

Lubrication. In lubricating a compound engine two-thirds of the oil for cylinder lubrication should be fed to the

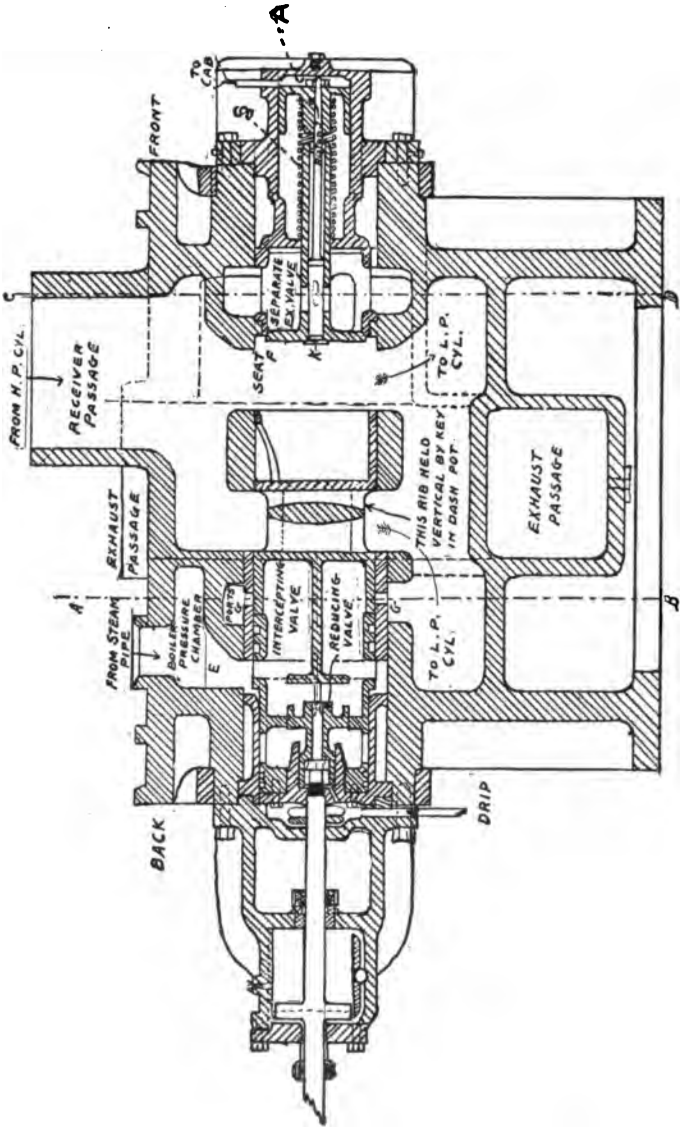

TO CAB
FRONT
FROM H. P. CYL.
RECEIVER PASSAGE
SEPARATE EX. VALVE
SEAT F
TO L. P. CYL.
THIS RIB HELD VERTICAL BY KEY IN DASH POT
EXHAUST PASSAGE
EXHAUST PASSAGE
FROM STEAM PIPE
BOILER PRESSURE CHAMBER
INTERCEPTING VALVE
REDUCING VALVE
TO L. P. CYL.
BACK
DRIP

Fig. 119.

high pressure cylinder while using steam. When drifting for a long distance this rule should be reversed, but the amount of oil used can be lessened by using a little steam.

The necessity for feeding more oil to the high than to the low pressure cylinder is due to the higher pressure of steam in the high pressure cylinder, which causes more friction than exists in the low pressure, and the oil that is fed to the high pressure cylinder is carried along with the steam to the low pressure, in a vaporized form.

Height of Water. Just enough water should be carried in the boiler of a compound engine to prevent overheating of the fire-box under all conditions of service, as wet steam is more injurious to a compound than a simple engine.

Starting. A compound engine when handling a heavy train should always be started as a simple engine.

Drifting. When drifting, the three-way cock in the cab should be in the same position as when working the engine simple, which will cause the separate exhaust valve to open (Fig. 118). The cylinder and port cocks should also be open.

Separate Exhaust Valve. A weak separate exhaust valve spring (Fig. 119) or the exhaust valve sticking, will cause two exhausts of air to blow from the three-way cock when the engine is being changed from simple to compound.

Steam blowing at the three-way cock indicates a leaky separate valve-seat, which allows steam to pass by the exhaust valve packing ring.

If the engine will not operate as a compound when pressure in the separate exhaust valve is released by the three-way cock it indicates that the exhaust valve is stuck and communication with the valve has not been closed. A small quantity of coal oil admitted through the three-way cock in the cab, and forced to the separate exhaust valve, fol-

lowed a short time afterward by a small quantity of cylinder oil, will generally release the valve.

Intercepting and Reducing Valve. If the engine stands with the high pressure side on the center and will not move when given steam the trouble is due either to a stuck intercepting or reducing valve, which will prevent direct communication between the boiler and the low pressure cylinder. The position of the intercepting valve-stem will show which valve is stuck. A light blow on the end of the stem after the throttle has been opened will move it ahead. If the stem is out only a few inches it indicates that the reducing valve is stuck. A few sharp blows on the intercepting valve back head, with the throttle opened, will usually loosen it, and communication will again be established between the boiler and the low pressure cylinder.

Breakdowns. In case of a breakdown the separate exhaust valve should be opened as it is when working simple (Fig. 118). The blocking should be placed, the ports covered, and the engine disconnected, in the same manner as with a simple engine.

To shut out the steam from the low pressure cylinder, place the valve centrally on its seat and the separate exhaust valve and intercepting valve in a position that will allow the engine to work as a simple engine.

Air Pressure Before Starting. It is very important that the air be pumped up on a Schenectady two-cylinder compound before the engine is started, if air is used to operate the separate exhaust valve, in order to insure a sufficient amount of air pressure to operate the valve, so that the compound can be operated as a simple engine.

Locating Blows. The method of locating blows on a two-cylinder compound depends entirely upon the type of engine. In locating blows or leaks of valve or cylinder packing, the tests are similar to those made on a simple engine, and the engine should be worked as a simple engine

while locating them. To test for blows in the intercepting valve, the right-hand crank pin should be placed on the top or bottom quarter, the reverse lever placed in the center of the quadrant, the intercepting valve closed and the separate exhaust valve opened. Steam can then pass through the separate exhaust valve and will appear at the exhaust nozzle if the intercepting valve blows.

BY-PASS AND OVERPASS VALVES.

The by-pass valves are connected with the steam ports, and their purpose is to afford communication between the steam-chest and the steam ports in the cylinder. They are used to relieve the cylinder from excessive back pressure when drifting.

The purpose of the overpass valves in the Richmond compound engine is to prevent a vacuum from being formed in the steam-chest, and the cylinders from heating. While

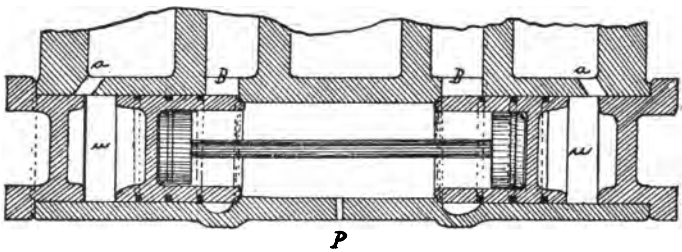


Plate 17, Fig. 1.

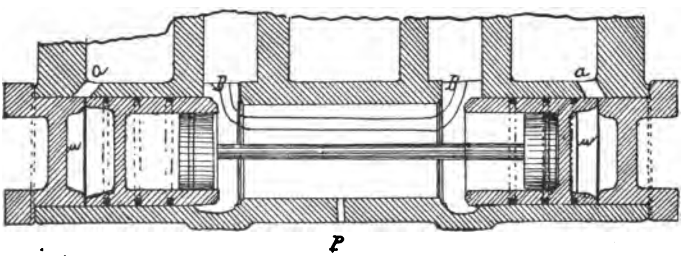


Fig. 2, Plate 17.

the throttle is open the passages *a-a* and chambers *u-u* are filled with steam and the overpass valves are held closed (Fig. 1, Plate 17). When the throttle is closed and the locomotive is allowed to drift, a vacuum forms in the steam-chest. This causes a vacuum to be formed in chambers *u-u* on each side of the overpass valves and the valves are forced apart. This opens passage BB from one end of the cylinder to the other, and the air that is being compressed ahead of the piston is free to flow into the other end of the cylinder (Fig. 2, Plate 17), thus preventing to a considerable extent the formation of a vacuum. The space between the valves is connected with the atmosphere through the small vent P, as it has been found advisable to admit some external air in order to prevent the cylinders from becoming overheated through the heat generated in churning the air back and forth in the cylinder. The vent also aids in preventing the formation of a vacuum. The overpass valves are used only on the low pressure cylinders.

BROOKS TANDEM TYPE.

The four-cylinder Brooks compound type locomotives are called tandems for the reason that both pistons are operated by the same piston rod, and the high pressure cylinders are ahead of, and connected to, the low pressure cylinders.

In the tandem compound the steam does not exhaust from the right to the left cylinder, as is the case with the cross compound, but passes from the high pressure cylinder to the low pressure steam-chest on the same side.

The valves on the tandem compound are designed for both inside and outside admission. Fig. 121 shows the inside admission for both valves. The steam ports are so arranged that both valves can be operated by one valve rod. On the high and low pressure cylinders, the valves are

arranged for internal admission and the steam ports are opened and closed at the same time by the valve. On the low pressure cylinders the valves are also arranged for internal admission. The steam ports are the same as those used on the high pressure cylinder and the ordinary type of engine.

When the engine is working compound, steam is admit-

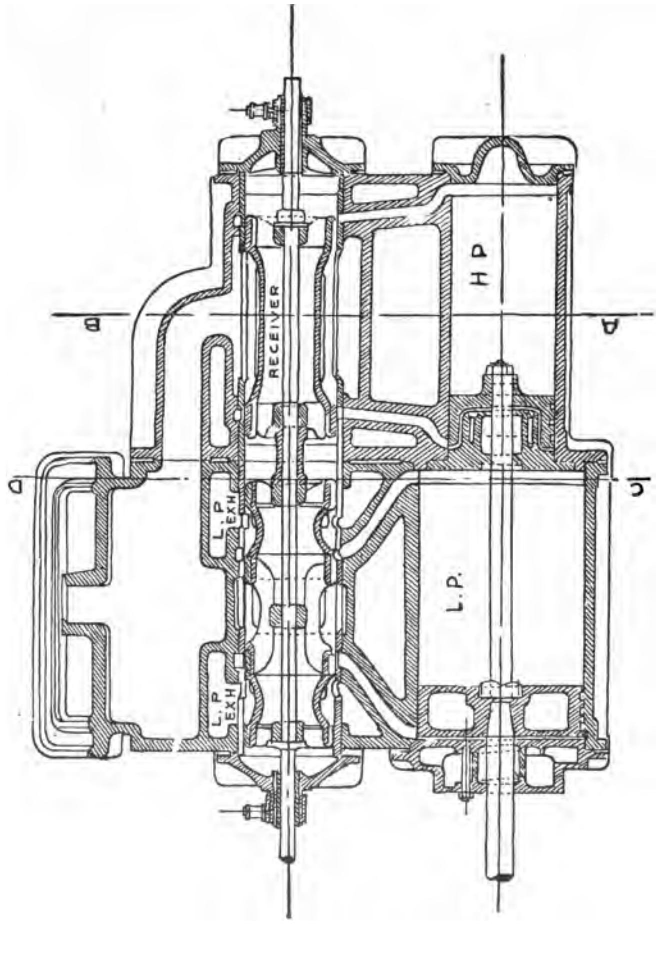


Fig. 121.

ted to the high pressure steam-chest (Fig. 121) through the connecting pipes, into the supply cavity surrounding the high pressure piston valve, and thence through the admission ports to the high pressure cylinder. When the valve in the high pressure cylinder is open for the admission of

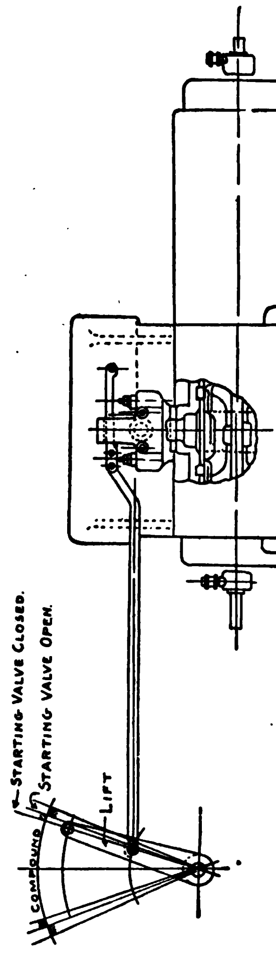


Plate 18, Fig. 1.

steam, the steam will pass down to the cylinder in the same manner as with an inside admission piston valve. The exhaust from the back head of the high pressure cylinder passes into the receiver, and that from the front end through the hollow piston valve, the steam being admitted to the low pressure cylinder by the internal edge of the valve and exhausted therefrom through the extra exhaust passages on the end of the valve, to the stack.

Operating Tandem as Simple Engine. A tandem compound can be operated as a simple engine only with the reverse lever in full gear. The low pressure steam-chest is provided with a reducing and starting valve, connecting with the high pressure steam-pipe. This valve is permitted to operate automatically when the reverse lever is in full forward or backward gear. In the intermediate position of the lever it is locked to its seat by a spring, so that it is rendered inoperative. Fig. 1, Plate 18, shows the range of the lift shaft arm for the starting valve to be either opened or closed. The combination starting and reducing valve permits the introduction of steam into the low pressure cylinder at an equivalent to the maximum pressure obtained in this cylinder when the engine is working compound. Fig. 2, Plate 18, shows the starting valve open. As soon as the engine has made one complete revolution and the receiver is charged with the exhaust steam from the high pressure cylinder, the starting valve becomes inoperative, causing the engine to work compound. Fig. 3, Plate 18, shows the starting valve closed.

The high pressure steam port and the passage surrounding the by-pass valve have communication with the starting valve.

The starting valve, which causes the engine to work simple, and which can be operated by a lever in the cab, admits steam directly to the low pressure cylinder. Steam is first admitted to the high pressure steam-chest through

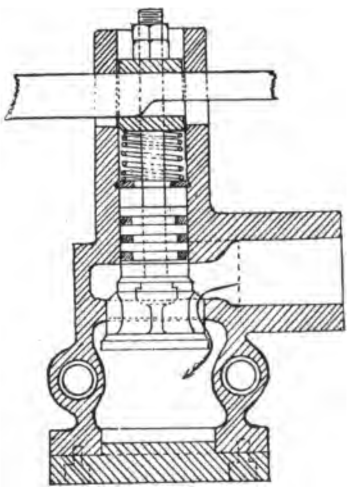


Fig. 2.

Plate 18.

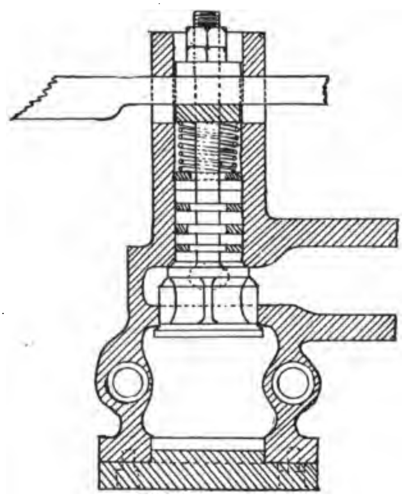


Fig. 3.

the short steam-pipe connecting the saddle and the steam-chest, passing through the ports and around the by-pass valve, which registers with the high pressure steam ports. The by-pass valves are held against their seats by the pressure from below, which is in direct communication with the steam-chest. The starting valve having thus established communication with both high pressure steam ports, steam passes through both hollow piston valves and is admitted to the low pressure cylinder. The by-pass valves are also in the starting valve casting.

Lubricators on Tandems. A tandem compound engine is usually equipped with two double sight-feed lubricators or one five-feed lubricator. When two lubricators are used each feed lubricates one of the four valves and the pistons, and with the five-feed lubricator one feed leads to each of the four cylinders, the other to the air-pump. The high pressure cylinders will require a greater supply of oil than the low pressure cylinders.

Breakdowns on Tandems. In case of a breakdown on the road, the Brooks tandem compound should be disconnected, the crosshead blocked and the steam ports covered, in the same manner as with a simple engine.

Difference in Types. In a four-cylinder tandem one cylinder is placed behind the other, while in the Vauclain compound one cylinder is placed above the other.

A tandem compound engine has four main steam valves, while a Vauclain compound has but two.

The low pressure cylinders are made larger than the high pressure cylinders in order to equalize the pressures.

Purpose of Working Single Expansion. To simple a compound engine is to work it single expansion. The purpose of doing this is to increase the power by using live steam from the boiler direct to the low pressure cylinder.

VAUCLAIN TYPE FOUR-CYLINDER.

With the Vauclain type when working compound, steam is admitted from the dry pipe into the steam-pipe and passes to the steam-chest, and then into the high pressure cylinders and is exhausted through the hollow of the valve to the low pressure cylinder and thence to the exhaust past the end of the valve (Fig. 123). When working as a simple engine, steam is admitted directly from the steam-chest to the starting valve, and passes through the hollow of the valve to the low pressure cylinder (Fig. 124), and thence to the exhaust. The high pressure pistons, having equal pressure on both sides, owing to the low pressure cylinder taking steam direct from the high pressure steam-chest, prevent the high pressure cylinder from exhausting into the low pressure, and have no effect on the working of the engine.

Engine Drifting. When drifting down grade the reverse lever should be in full gear and the starting valve open as when working simple (Plate 19, Fig. 1). Plate

19, Fig. 2, shows position for the starting valve when working compound. Plate 19, Fig. 3, shows this valve acting as a cylinder cock for both ends of the high pressure cylinder. All three positions of the starting valve as shown in Plate

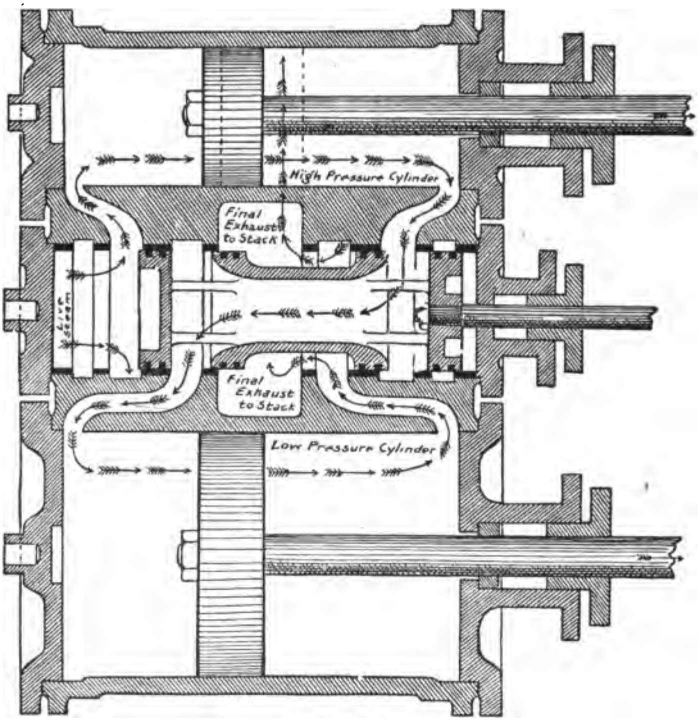


Fig. 123.

19 are controlled by the same lever which operates the cylinder cocks.

With engines not equipped with oil pipes leading to the low pressure cylinder, a little steam should be worked while drifting, to keep the cylinders lubricated.

TESTING FOR BLOWS.

When testing for valve blows in a Vauclain compound, the engine should be placed on the quarter, the reverse lever

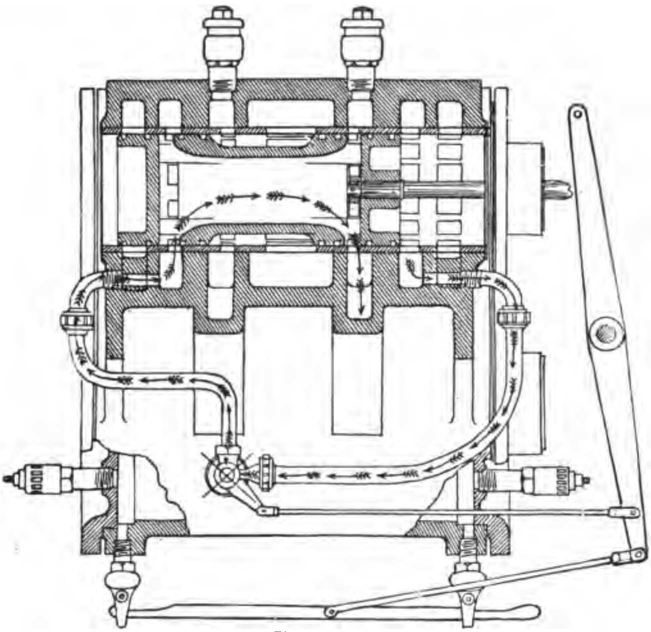


Fig. 124.

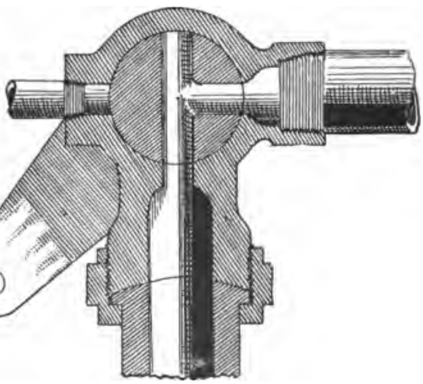


Plate 19, Fig. 1.

in the center, the cylinder cocks and starting valve opened and a little steam admitted to the valve. If the two extreme end rings 1 and 2 leak, steam will blow steadily from the starting valve. To determine which ring leaks or is broken, disconnect the coupling nut on the pipe which conveys steam to the starting valve, and the end of the pipe at which

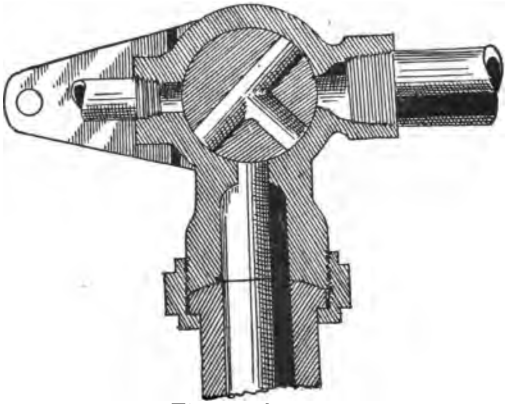


Fig. 2, Plate 19.

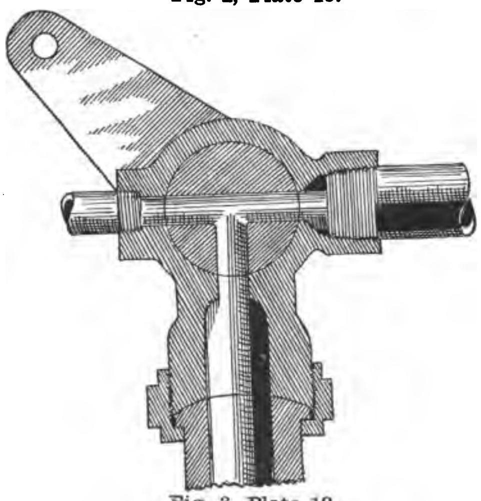


Fig. 3, Plate 19.

the steam appears will indicate which one is broken. If testing for No. 3 and 4 valve rings, place the engine on the quarter, close the starting valve and open the cylinder cocks, and move the reverse lever from the centernotch toward the end of the quadrant, either forward or back, depending upon which ring is being tested, which will move the valve, causing ring No. 1 or 2 to come over the admission port. This will admit steam to one end of the cylinder. If the valve is moved back and ring No. 3 is the one which is broken, steam will pass by the broken ring, down the front port to the low pressure cylinder and out of the front cylinder cock. If the valve is moved ahead to a position which places ring No. 2 over the back admission port, when ring No. 4 is broken, steam will pass by ring No. 4, down the passage to the back head of the low pressure cylinder and out of the back cylinder cock.

Should rings No. 5 or 6 be broken, it has very little effect when working compound, but allows steam entrapped in the hollow of the valve to be admitted to the low pressure cylinder too early. This will be indicated by the cylinder cocks. A broken ring No. 5 or 6 can better be detected by having the starting valve open and reverse lever down. Then open the cylinder cocks and admit steam, and move the engine slowly. Note the cross-head as it nears the end of its stroke, and if steam is admitted too early for that end of cylinder it indicates that ring No. 5 or 6 is broken.

When either No. 7 or 8 valve ring is broken, it will cause a blow just before the exhaust takes place, and will also cause a light and early exhaust. This can be determined by watching the crosshead and noting from which end of the cylinder the light exhaust comes.

A broken admission ring No. 1 or 2 in the high pressure valve gives too early a port opening to the high pressure cylinder and cuts off the steam too late. This allows too much steam to be admitted to the high pressure cylinder

and when the steam is exhausted to the atmosphere it will be indicated by a heavy exhaust. Fig. 126 shows a sectional view of the valve placed centrally on its seat and the arrangement of the ports.

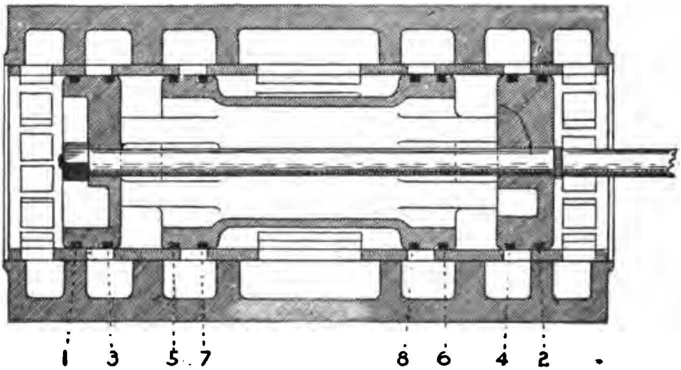


Fig. 126.

When testing for a valve blow in a tandem compound, the engine should be placed on the quarter, the brake set, the ports covered, the cylinder cocks on the high pressure cylinder blocked open, and the engine given a full head of steam. If no steam appears at the cylinder cocks it indicates that the two admission rings are in good condition. If, however, the steam blows out of either or both cylinder cocks, it indicates that the rings are leaking or broken. To test the low pressure valves, the starting valve should be opened, the cylinder cocks on the low pressure cylinder opened and steam admitted. If there is a blow past the inside admission rings, it will show at the cylinder cocks. If the valve has exhaust clearance it will also blow to the stack. The cylinder cock from which the steam appears indicates the end of the valve on which the ring is broken. If the exhaust rings are broken on the low pressure piston

valve, it will be indicated by a light and early exhaust from the end of the cylinder in which the ring is broken.

The method of testing for blows in the high and the low pressure cylinder packing is practically the same for both the Vauclain and the tandem. In testing for a blow in a high pressure cylinder packing of a tandem, the engine should be placed on the bottom quarter on the side to be tested, the reverse lever placed in the forward motion and the back cylinder cock of the high pressure cylinder blocked open. This will admit steam to the front head, and, if it then blows from the back cylinder cock, it indicates that the high pressure cylinder packing is blowing. In testing for the low pressure cylinder packing, the engine and reverse levers should be placed in the position required for testing for high pressure cylinder packing and the back cylinder cock of the low pressure cylinder blocked open. The starting valve should be opened and a little steam admitted. If steam then blows from the back cylinder cock, the blow is in the low pressure cylinder packing.

When testing for cylinder packing on a Vauclain, place the engine on the quarter, the reverse lever in the full back or forward position, open the cylinder cocks and admit steam to the high pressure cylinder. If the packing blows, steam will pass from the opposite end of the high pressure cylinder, the exhaust being open from that end of the cylinder, to the opposite end of the low pressure cylinder, and will pass out of the cylinder cock. This indicates that the high pressure cylinder packing is blowing. To test for low pressure cylinder packing, place the engine on the quarter, with the reverse lever in full stroke, open the starting valve and admit steam to the low pressure cylinder. If steam is admitted to the front head and the cylinder packing is blowing, it will be indicated at the back cylinder cock and stack.

A blow in a sleeve between the high and low pressure cylinders of a tandem can be located by placing the engine

on the top quarter on the side to be tested, placing the reverse lever in the forward motion and blocking open the front cylinder cock of the low pressure cylinder. A little steam should then be admitted to the back end of the high pressure cylinder. If the steam blows out of the front cylinder cock of the low pressure cylinder and also at the stack, it indicates that the sleeve is not steam-tight.

SLIPPED ECCENTRIC.

A slipped eccentric on either a tandem, Vauclain, or a cross compound engine should be set in the same manner as with a simple engine.

DISCONNECTING.

If it is necessary to disconnect on one side of either a tandem or a Vauclain compound engine, the rocker arm should be plumbed, the valve-stem disconnected and clamped with a valve clamp, or, if no clamp is at hand, a block of wood placed between the valve-stem and the frame to prevent the rocker arm from striking the stem, and secured in the same manner as with a simple engine.

When disconnecting a Vauclain compound engine for a broken high or low pressure piston rod, the valve on the broken side should be disconnected and clamped on the center of its seat and the main rod taken down. If the main rod is too heavy to take down, or the distance to be covered is short, the indicator plugs or the relief valve should be taken out, and the cylinder oiled, if the piston is not broken, and the engine run on one side.

WORKING SIMPLE FOR LONG DISTANCES.

A compound engine should not be worked simple for ong distances, or when unnecessary, as it causes strain and wear of the valve gear, in addition to wasting fuel.

SANDING RAILS.

It is important that the rails be sanded when starting a compound in simple position, as on account of the additional power exerted on the piston the drivers are more likely to slip than when working compound.

WORKING ENGINE WITH SHORT CUT-OFF.

It is considered a disadvantage to work a compound engine with short cut-off on account of the greater compression. The power of both cylinders is better equalized with the lever at one-half stroke.

LIGHT TRAINS.

A compound engine working with a partial load should be operated with the reverse lever at the half stroke, and with a light throttle. If the engine develops more power than is required with the lever at about half stroke, the throttle should be partly closed.

OPENING CYLINDER COCKS.

It is more important to have the cylinder cocks open when starting a compound engine than when starting a simple engine, as there is more condensation in the cylinder of a compound than of a simple engine.

WALSCHAERT VALVE GEAR.

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The Walschaert valve gear, though but lately introduced on any large scale in American locomotive practice, is as old a device as the Stephenson shifting link motion, with which every engineer is familiar. In 1844 Egide Walschaerts, at that time Chief Shop Superintendent of the Brussels Southern Railroad, invented the type of valve motion which bears his name. Because of the fact that the rules of the railway company did not allow a foreman in the shops to advertise a patent in Belgium to his own profit, the application for the patent was made by M. Fischer, Engineer of the State Railways of Brussels, a friend of Walschaerts', in the latter's name. The patent was granted by Royal Decree on Nov. 30, 1844, and the mechanism described in the patent resembles the motion which is now in use on many American locomotives. The so-called Stephenson shifting link motion came into prominence a year earlier, or in 1843. The Walschaert valve gear attracted a great deal of attention in Europe and gradually became the accepted type of valve motion on the railroads of Continental Europe, just as the Stephenson link motion came into general use on American railroads.

Although there are a number of special cases in which the Walschaert valve gear has been applied to locomotives in this country as far back as 20 or 25 years ago, it is only during the last few years that it has been used in America on any large scale. With the increase in power and weight of the modern locomotive, however, conditions have arisen to meet which the American designer has turned to the Walschaert valve gear because it offers certain mechanical and structural advantages over the Stephenson motion.

Because of the increase in size of the parts, there is hardly room enough between the frames of a modern heavy

freight or passenger engine for the accommodation of the Stephenson gear. The eccentrics are crowded together so that it is almost impossible for the engineer to give them proper inspection or lubrication. The Walschaert valve gear, on the contrary, being outside of the frames, is perfectly accessible, and can therefore be much more easily maintained.

With the high surface velocities of the largest sizes of eccentrics, it is difficult to keep them properly lubricated. With the Walschaert valve gear, there are no large eccentrics to keep lubricated; but with hardened pins and hardened bushings it has an important advantage in maintenance.

The Walschaert gear transmits the moving force to the valve in very nearly straight lines, so that there is less springing and yielding of the parts than in the Stephenson link motion.

The Stephenson link, under the influence of the two eccentrics, moves through wide angles, resulting in a wedging action of the link block which strains the gear and produces lost motion. The Walschaert link, driven by a single eccentric, moves through smaller angles and produces less lost motion.

By removing the valve gear from between the frames, as we do in the case of the Walschaert gear, a better opportunity is afforded to introduce stronger frame bracing, and thus reduce the possibility of frame failures.

The Walschaert valve gear shows a distinct advantage over the Stephenson link motion as regards permanence of adjustment. When a large freight engine is half way between shoppings the Stephenson link motion is slack and loose, while the Walschaert valve gear is in as nearly good condition as when the engine left the shop; consequently the original steam distribution is much better maintained with the Walschaert than with the Stephenson motion.

These are some of the reasons why a large number of American railroads are now equipping their engines with the Walschaert valve gear. Seldom in the history of the development of the locomotive in this country has any improvement, once introduced, been so rapidly accepted as this type of valve motion; and, inasmuch as its use will undoubtedly increase, a clear understanding of its principles and construction is essential for all those who operate engines so equipped.

Form of Valve Motion. The best place to begin is always at the beginning; and as the Walschaert valve motion, like any other device, is merely a development of some simpler form, it is necessary in studying it to start with the original form and trace the various steps in the development.

Figure 127 represents the simplest form of valve motion; viz., a single eccentric of the return crank form, driving a plain normal valve without lap or lead by means of an eccentric rod directly connected to the valve stem. Assuming that the engine is to run forward, with the main pin on the back center, as shown, the eccentric crank pin must be on the top quarter; in which case the valve will be in the central position on its seat with all ports closed. Although it is apparent that if the throttle were open this engine could not start of itself, with another engine of the same kind connected to the wheel on the other side of the axle, and with the main pins at right angles to each other, as is the case in the locomotive, the valve of the left hand engine would be in a position to admit steam behind the piston and start the wheels turning to the right. The eccentric crank on the engine which is shown would then move the valve forward, uncovering the back steam port and admitting steam behind the piston, and the engine would run forward. It is perfectly evident, however, that this engine will only run in one direction; for if, to start it backward, the wheel

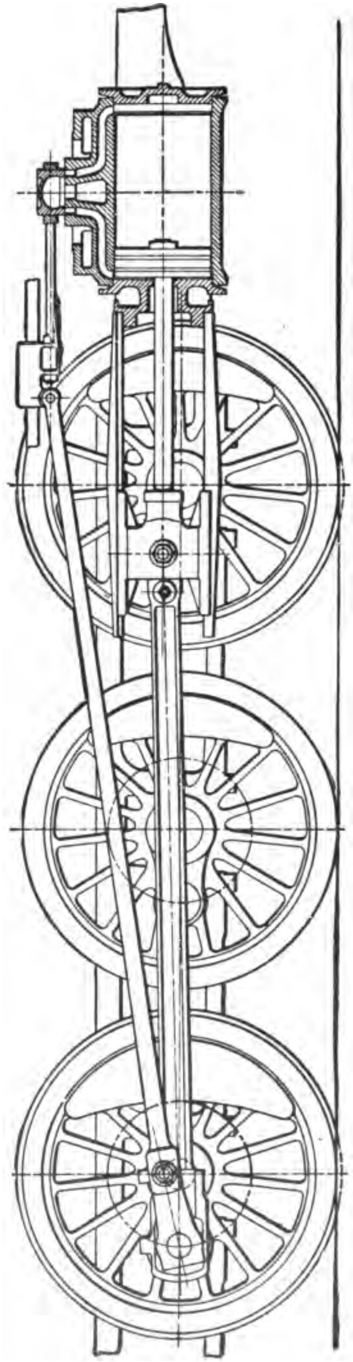

Fig. 127.

was pinched to the left, with the eccentric in the position as shown, the valve would be moved to the left and steam admitted ahead of the piston, forcing the crank pin back again to its position on the back center. In order to make the engine run backward, the eccentric would have to be in the opposite position from that which it occupies, or on the lower quarter; in which case as the wheel was turned to the left or backward the eccentric would be a quarter of a revolution ahead of the main pin and move the valve forward, opening up the back port and admitting steam behind the piston as is necessary.

The first thing to do in the development of this simple form of engine, therefore, is to introduce some means by which it can be reversed. This can be accomplished by introducing a beam between the eccentric and the valve stem, pivoted at its center so that one end moves with and in the same direction as the eccentric and the other end in exactly the opposite direction.

Such a construction is shown in Fig. 128. With the valve stem at the lower end of the link and the main pin on the upper quarter, as shown in diagram "A," the eccentric will have moved the valve to its extreme forward position and the back port will be opened for the admission of steam behind the piston and the engine will run forward. If, however, with the main pin and eccentric crank in the same position, the valve stem was connected to the upper end of the link, as shown in diagram "B," the valve would be moved to its extreme position to the left and the front port would be opened and steam admitted ahead of the piston and the engine would run backward. With a flexible valve stem, or radius rod, connected to a block which slides in a curved slot in the beam, or link, as shown, and with the necessary mechanism for raising and lowering the block, it is evident that we now have an engine that can be reversed.

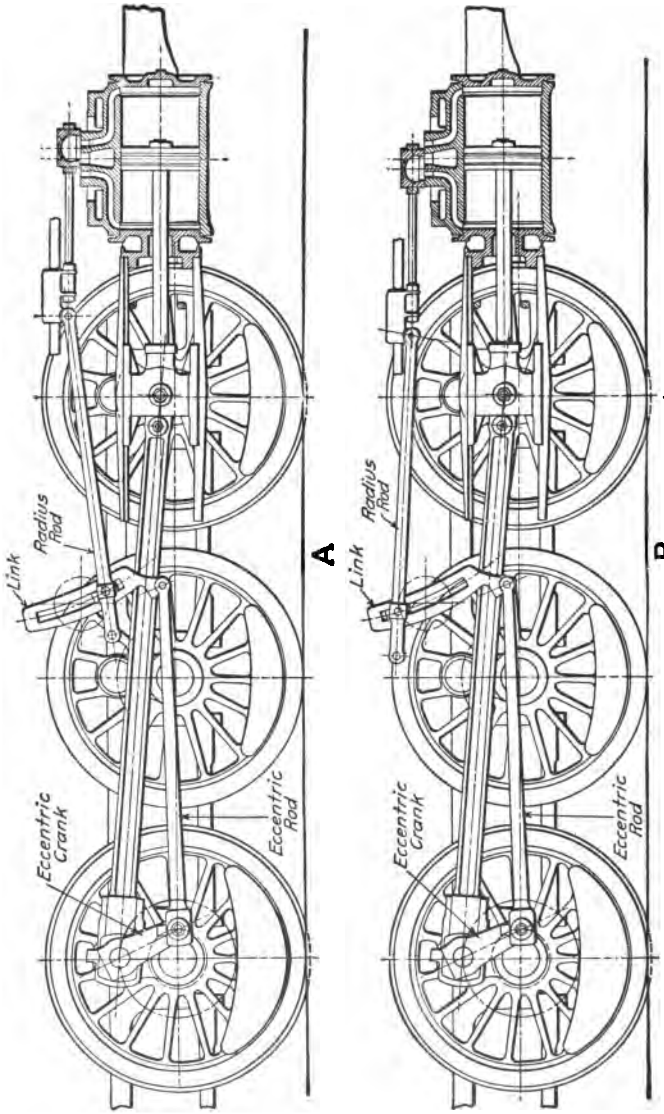
Link
Radius Rod
Eccentric Crank
Eccentric Rod
A
Link
Radius Rod
Eccentric Crank
Eccentric Rod
B

Fig. 128.

Valve Lap and Lead. The engine, however, is still far from an efficient machine; for, as the valve does not close the port for the admission of steam until it is in its central position on the seat; and, as with the eccentric only a quarter of a revolution ahead of the main pin, it is not in this position until the main pin is on the center, whatever the travel of the valve, steam will be admitted to the cylinders throughout the full stroke of the piston, and the engine will use as much steam working against a light as against a heavy load. In order to govern the period for the admission of steam, or, in other words, give a variable cut-off, the valve must be redesigned so that it will close the steam port before it reaches its central position; that is, it must be given "lap," the lap of a valve being that portion of it which over-laps the steam ports when it is on its central position on the seat. But with lap given to the valve and also "lead," which is the width of the opening of the steam port given by the valve when the piston is at the beginning of its stroke, the valve motion must be so changed that the valve will be advanced from its central position on the seat a distance equal to the amount of the lap plus the lead, when the crank pin is on either of the centers.

It is apparent, from an examination of Fig. 129, that this advance of the valve cannot be obtained by any change in the position of the eccentric crank relative to the main pin. Figure 129 shows the same valve motion as was shown in Fig. 128, except that the valve has one inch outside lap and the eccentric crank has been advanced to more than a quarter of a revolution ahead of the main pin. If then the link block is at the bottom of the link, as in position "A," the advance given to the eccentric will have moved the valve forward a distance equal to the lap plus the lead, and the back port will be opened for the admission of steam and the engine will run forward. If, on the other hand, the link block is moved to the upper end of the link, as shown in

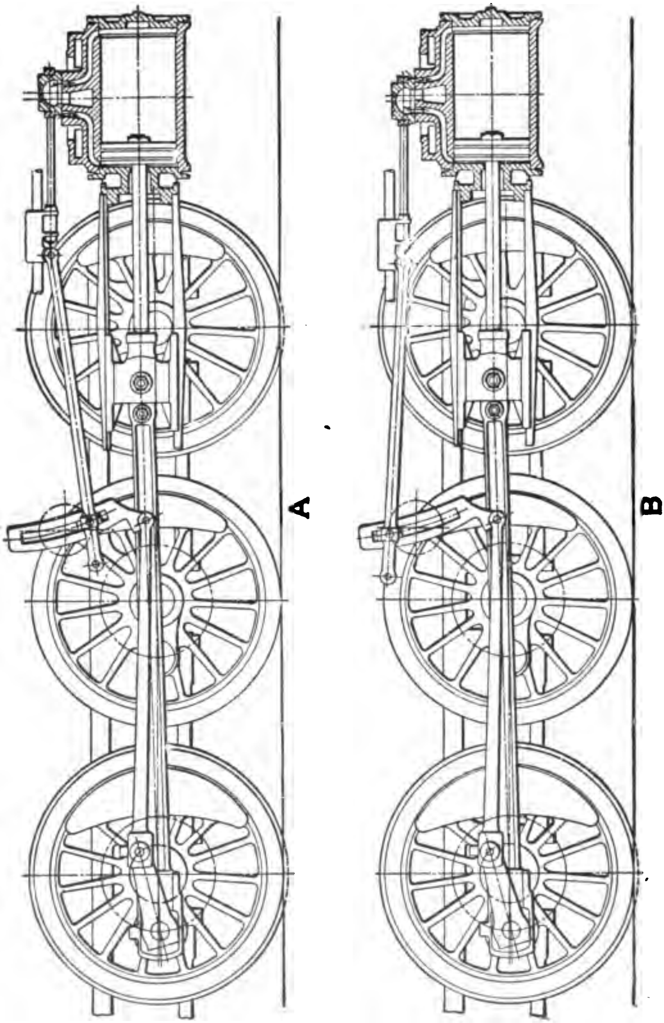

Fig. 129.

position "B," the advance given to the eccentric crank will have had the opposite effect and the front port will be opened and the reversibility of the engine thus destroyed. In order to provide lead, therefore, in any engine where there is but one eccentric, some means must be employed other than advancing or receding the position of that eccentric relative to the main pin; if there is to be any method of reversing the engine.

In the Walschaert valve gear the motion for providing lap and lead to the valve is derived from the main pin by suitable connections with the crosshead.

Valve Lap and Lead Lever. This brings us to the next step in the development of the Walschaert valve gear and the introduction of the lap and lead lever. Suppose that our link block is in the center of the link as shown in position "A," Fig. 130. As the center of the link block coincides with the center of the link support, there will be no movement of the radius rod as the link swings back and forth through the action of the eccentric. If then the radius rod was connected with the lap and lead lever at the point "R;" and the upper end of the lever was connected to the valve stem crosshead at "V;" and the lower end to the crosshead arm by means of a short link, as shown, as this latter moves back and forth, the point "R" being fixed, the point "V" will rotate about it and the valve will be moved back and forth. With the main pin on the forward center, as shown in position "A," the angle assumed by the lap and lead lever has moved the valve back a sufficient distance to uncover the front port. With the main pin on the back center, as shown in position "B," the lap and lead lever is inclined in the opposite direction and the valve moved forward, and the back port is open. This is the way the Walschaert valve gear derives its lead. The distance between the connecting points of the lap and lead lever must be so proportioned that the travel of the crosshead from one end

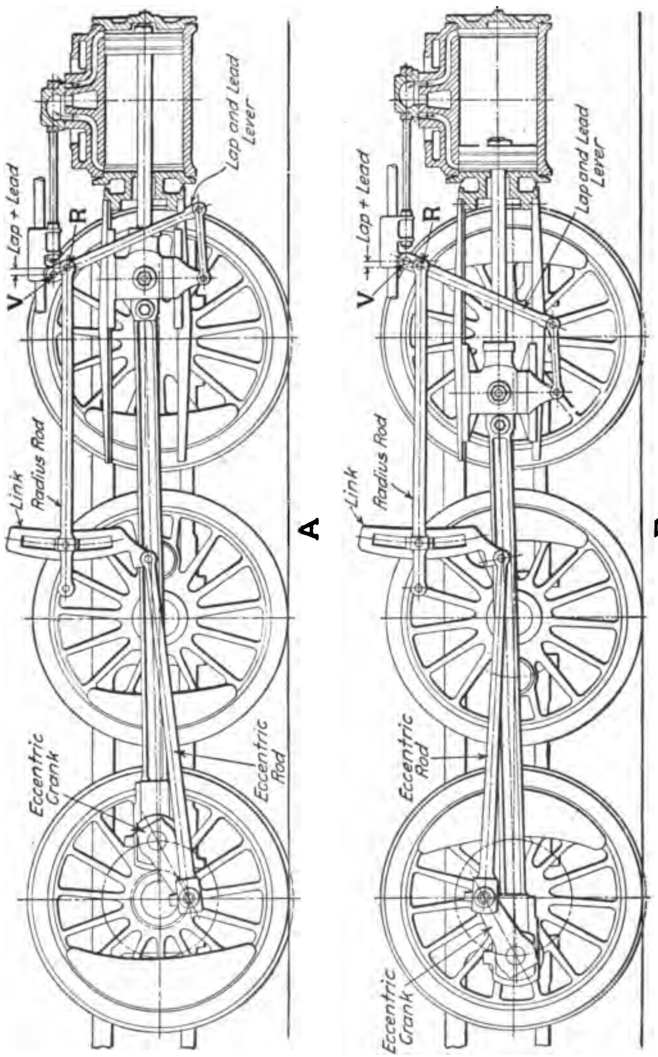
Lap and Lead Lever
Lap + Lead
V
R
Link
Radius Rod
Eccentric Crank
Eccentric Rod
A
B

Fig. 130.

of the stroke to the other will give a travel to the valve equal to twice the lap plus the lead. That this lead is permanent and does not vary as the reverse lever is hooked up will be shown later on.

The position of the eccentric crank relative to the main pin depends on which end of the link is used for forward motion. If the forward motion is taken from the bottom of the link, as is usually the case, the eccentric crank is a quarter of a revolution ahead of the main pin when the wheel is running forward, if the valves have outside admission; and a quarter of a revolution behind it, if the valves have inside admission. If the top of the link is used for forward motion, the eccentric crank is a quarter of a revolution behind the main pin, if the valves have outside admission; and a quarter of a revolution ahead of it, if the valves have inside admission. In all cases, if the valves have outside admission, the radius rod is connected to the lap and lead lever below the valve stem, and above it, if the valves have inside admission.

The simple form of direct valve motion, shown in the first figure, has now been so modified that the engine is reversible and has a variable cut-off. It only remains to provide the necessary reversing mechanism and we have the Walschaert valve gear in its complete form as shown in Fig. 131, which represents its application to a consolidation engine.

Figure 132 shows a general outline of the gear as arranged for inside admission valves on which are given the names of the various parts as recommended by the American Railway Master Mechanics' Association. Starting at the crank pin, we have the eccentric crank, eccentric rod, link, reach rod, lift shaft, radius rod hanger, radius rod, lap and lead lever, lap and lead lever connector, and crosshead arm.

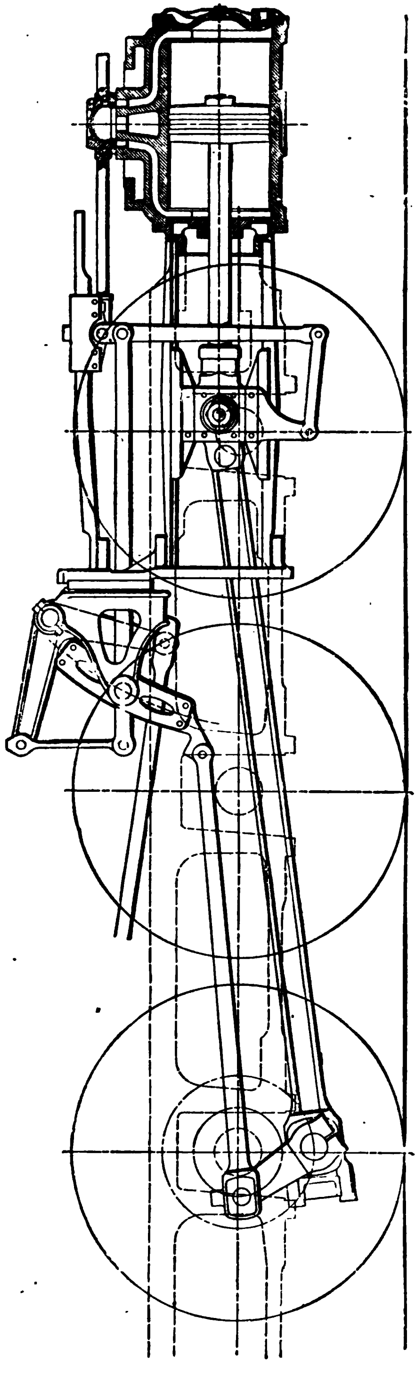

Fig. 131.

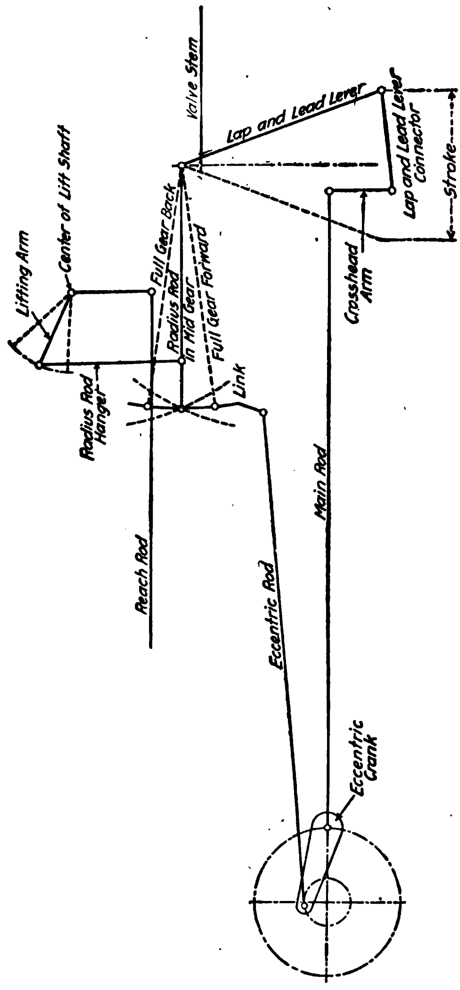

Fig. 132.

Movement of the Valve Through a Complete Revolution of the Wheel. Having studied the functions of the different parts of the Walschaert valve gear, it remains to trace the movement of the valve through a complete revolution of the wheel. Figures 133, 134, 135 and 136 show a

series of diagrams representing different positions of the valve for different positions of the crank pin. For the sake of simplicity, the valve and cylinder are shown in section, while the other parts of the gear are represented by their center lines and center points only. As will be apparent, these diagrams are out of proportion, the valve and the eccentric throw having been enlarged in order to bring out more clearly the positions of the edges of the valve relative to the edges of the cylinder ports. In Fig. 133, the valve is outside admission and the motion is represented as being in full forward gear; or with the reverse lever in the extreme forward position. Figure 134 represents the same valve motion, but in this case the reverse lever is hooked up and the link block is nearer the center of the link and the engine is cutting off at about 25% of the stroke. Figures 135 and 136 represent a valve motion as arranged for an inside admission piston valve; in Fig. 135, the motion being in full gear forward; while in Fig. 136 it is represented with the reverse lever hooked up.

As has already been shown, the valve receives its motion from two distinct sources: first, from the eccentric crank, which gives the long travel to the valve; and second, from the crosshead by means of the lap and lead lever, which would give a short travel to the valve even if the eccentric rod was disconnected.

Starting with diagram 1, Fig. 133, as the valve is outside admission, with the main pin on the back center, the eccentric crank is on the top quarter, or a quarter of a revolution ahead of the pin, and the radius rod is connected to the lap and lead lever below the valve stem. The link is in its central position, and the valve would be in its central position on the seat; if it were not for the motion given to it by the lap and lead lever. As it is, however, the crosshead being at the back end of the stroke, the lower end of the lap and lead lever is at its extreme back position and the

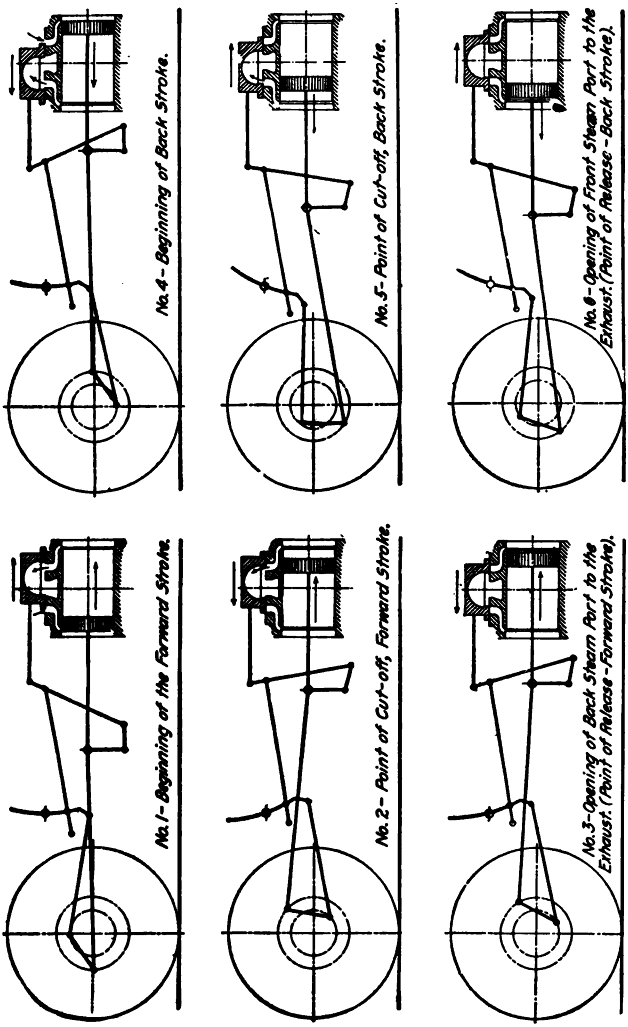
No. 1-Beginning of the Forward Stroke.
No. 2- Point of Cut-off, Forward Stroke.
No. 3-Opening of Back Steam Port to the Exhaust. (Point of Release-Forward Stroke).
No. 4 - Beginning of Back Stroke.
No. 5- Point of Cut-off, Back Stroke.
No. 6-Opening of Front Steam Port to the Exhaust. (Point of Release-Back Stroke).

Fig. 133.

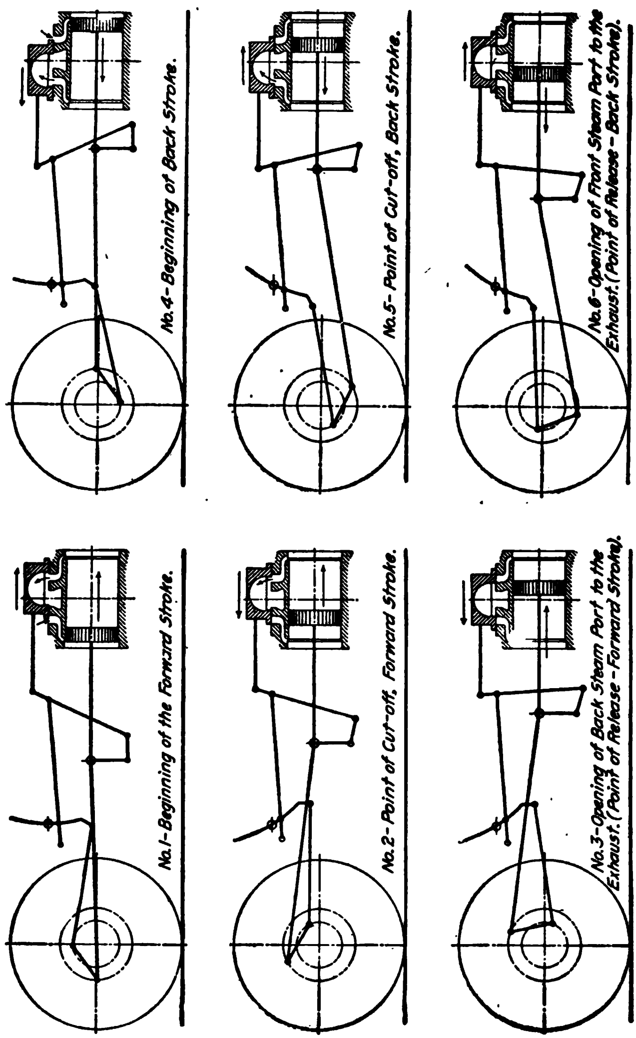
No. 1-Beginning of the Forward Stroke.
No. 2-Point of Cut-off, Forward Stroke.
No. 3-Opening of Back Steam Port to the Exhaust. (Point of Release-Forward Stroke).
No. 4-Beginning of Back Stroke.
No. 5-Point of Cut-off, Back Stroke.
No. 6-Opening of Front Steam Port to the Exhaust. (Point of Release-Back Stroke).

Fig. 134.

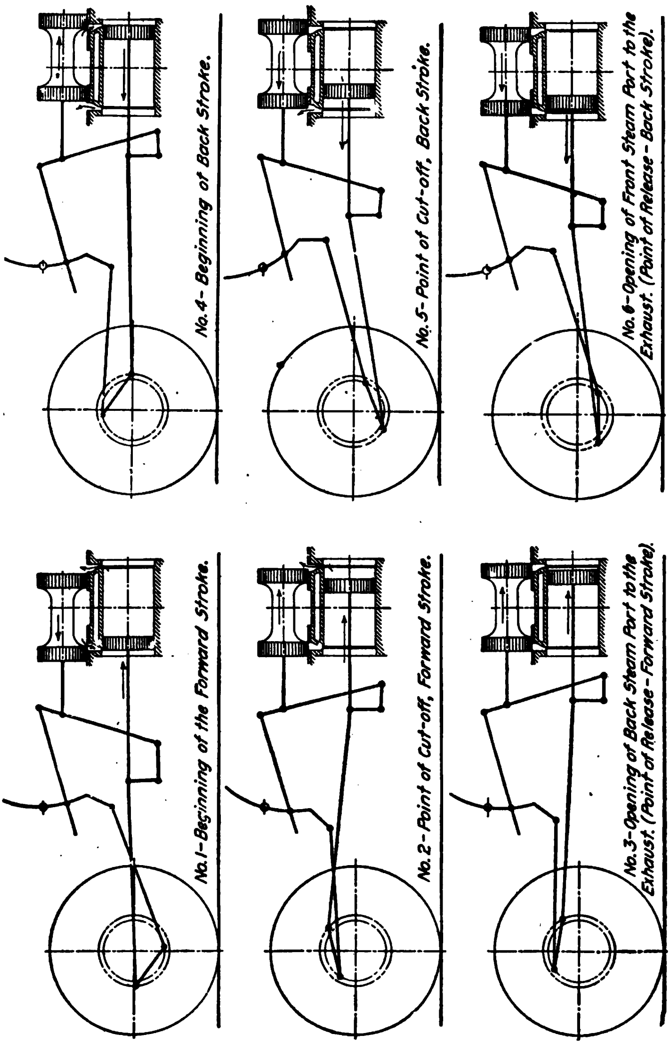
No.1-Beginning of the Forward Stroke.
No.2-Point of Cut-off, Forward Stroke.
No.3-Opening of Back Steam Port to the Exhaust. (Point of Release-Forward Stroke).
No.4-Beginning of Back Stroke.
No.5-Point of Cut-off, Back Stroke.
No.6-Opening of Front Steam Port to the Exhaust. (Point of Release-Back Stroke).

Fig. 135.

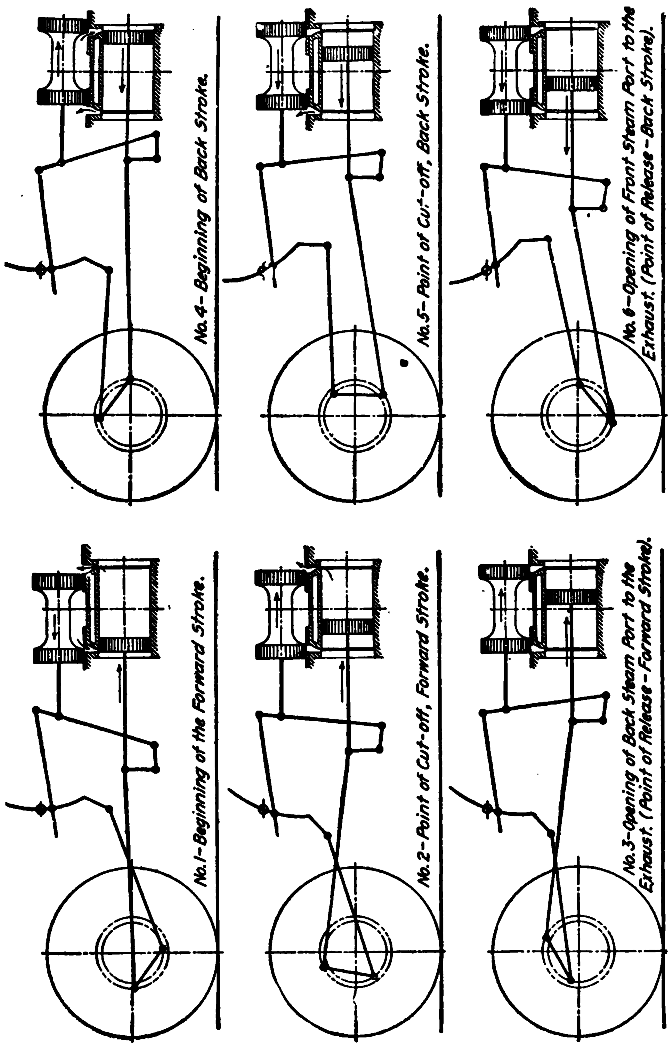
No. 1—Beginning of the Forward Stroke.
No. 2—Point of Cut-off, Forward Stroke.
No. 3—Opening of Back Steam Port to the Exhaust. (Point of Release—Forward Stroke).
No. 4—Beginning of Back Stroke.
No. 5—Point of Cut-off, Back Stroke.
No. 6—Opening of Front Steam Port to the Exhaust. (Point of Release—Back Stroke).

Fig. 136.

angle assumed by the lever has moved the valve forward, as indicated by the arrow, a distance equal to the lap of the valve plus the lead. Going to diagram 1, in Fig. 134, the main pin, eccentric crank and crosshead are in the same position as they were in the corresponding diagram in Fig. 133; and the link is in its central position. Thus, although the link block is nearer the center of the link, the radius of the link being equal to the length of the radius rod, the front end of the radius rod is the same horizontal distance from the center of the crosshead as it is in diagram 1, Fig. 133; consequently the angle assumed by the lap and lead lever is the same and the valve has been moved forward the same distance from its central position, and the lead is the same as it is with the reverse lever in full gear.

In Figs. 135 and 136, diagram 1 in each case represents the position of the valve at the beginning of the forward stroke; the same as the corresponding diagrams in Figs. 133 and 134. As the valves are inside admission, however, the radius rod is connected to the lap and lead lever above the valve stem. The valve, in each case, has thus been moved back, instead of forward, by the movement of the lap and lead lever; and the back port is open to the live steam and the front port, to the exhaust.

Going back to Fig. 133; in diagram 2, the piston has moved forward a distance equal to about 85% of the stroke; the valve has traveled to its extreme forward position and back again, as indicated by the arrow, till it has just closed the back steam port; while the front port is still open to the exhaust. In other words, the valve is at the point of cut-off. In diagram 3, the piston has moved still nearer to the forward end of the stroke. The exhaust edge of the valve is now in line with the edge of the back steam port; so that any further movement will open communication with this port and the exhaust. The front port, on the other hand, has been closed to the exhaust and whatever steam is ahead

of the piston will be compressed. In diagram 4, the piston is at the extreme forward end of the stroke; the angle assumed by the lap and lead lever has moved the valve back a distance equal to the lap plus the lead; the front port is open for the admission of steam and the back port is open to the exhaust. In diagram 5, the piston is moving toward the back end of the cylinder and the valve has just closed the front port to the admission of steam, showing the cut-off position of the valve on the back stroke. In diagram 6, the piston is very nearly at the end of the back stroke and the valve is about to open the front port to the exhaust; while the back port is closed to the exhaust and compression is taking place in the back end of the cylinder.

As the diagrams in Figs. 134, 135 and 136 represent the same valve events as the corresponding diagrams in Fig. 133, it will not be necessary to examine them separately. It will be noticed that in Figs. 134 and 136 the valve cuts off the steam from the cylinders and opens the steam ports to the exhaust at a much earlier period in both the forward and back stroke than it does in Figs. 133 and 135, which shows the effect of hooking up the reverse lever.

These diagrams show very plainly the difference in the arrangement of the Walschaert valve gear for outside and inside admission valves, also the fact that the lead of the valve is the same for all cut-offs.

Changing the Lead. To change the lead of the Walschaert valve gear, it is necessary to either change the lap of the valve, reducing it to increase the lead and increasing it to reduce the lead, in which case the cut-offs will occur at later or earlier periods in the stroke, respectively; or to change the lengths of the arms or distances between the connecting points of the lap and lead lever. Increasing the distance between the radius rod connection and the valve stem connection to the lap and lead lever would increase the lead; or shortening this distance would decrease the lead.

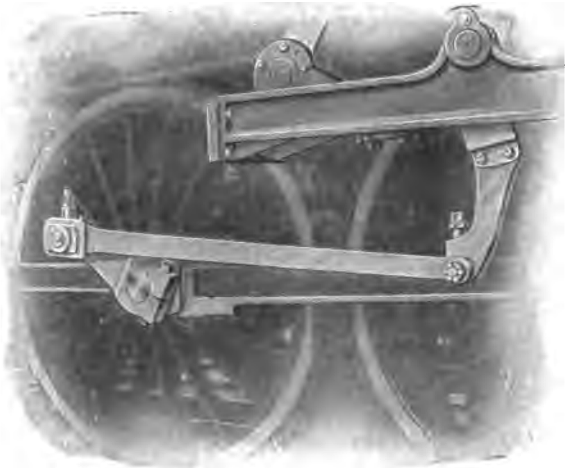

Fig. 137.

Just here it might be of interest to study some of the ordinary forms of construction of the various parts of the gear.

In Fig. 137 are shown an eccentric crank and eccentric rod. The eccentric crank, as will be seen, is secured to the extension of the main crank pin by a binding bolt. The crank is split so that it can be drawn to a tight bearing by means of the bolt. This bolt, together with a key, keeps the eccentric crank fixed in its position on the main pin. By driving out the binding bolt, the eccentric crank may be taken off if necessary. This construction permits of using a solid bushing on the side rod at the main crank pin.

The link and reverse shaft are shown in Fig. 138. In this design of gear, the radius rod is directly connected to the lift shaft arm by means of a slip block, which makes a very simple arrangement.

Different Style of Reversing Mechanism. Figure 139 shows another style of reversing mechanism. In this design,

Fig. 138.

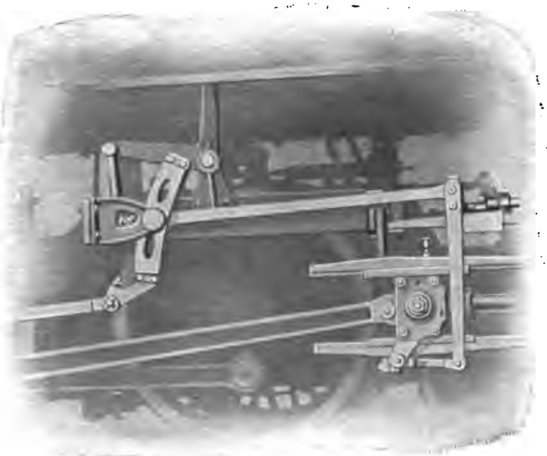

Fig. 139.

Fig. 140.

the backward extending arm of the lift shaft is connected to the back end of the radius rod by means of a link.

In Fig. 140 are shown the parts of the Walschaert valve gear connecting the valve stem and the crosshead. It will be noticed that the radius rod connection with the lap and lead lever is above the valve stem connection, showing that the valve is inside admission.

BREAKDOWNS, WALSCHAERT VALVE GEAR.

Having considered the principles of the Walschaert valve motion, the next phase of the subject to take up, and that which is of most interest to all engineers, is—what may be done in case of a breakdown. It would be impossible to lay down rules to cover every case that might arise; but we can take up some of the more usual or most possible failures and consider the best and quickest course to follow in such cases.

Broken Eccentric Crank, Eccentric Rod, Foot of Link, or Link Trunnion. Suppose, for instance, an eccentric crank, eccentric rod, or the foot of the link is broken; or one of the link trunnions twisted off, the other trunnion holding the link in position. In such cases, take down the eccentric rod, disconnect the back end of the radius rod from the lift shaft arm and secure the link block in the center of the link. With the motion disconnected and blocked in this way, the valve on the lame side receives a travel from the lap and lead lever equal to twice the amount of the lap plus the lead, which gives a port opening equal to the amount of the lead. This permits of leaving the main rod up and running in with both sides; as the cylinders can be lubricated and, though the cut-off will be very short on the disabled side, the steam that is admitted will do a certain amount of work and the engine can be reversed.

Figure 141 shows an engine with the valve gear disconnected and blocked as just described. In the design illustrated, the radius rod is connected to the lift shaft arm by means of a radius rod hanger so that it can be readily disconnected by taking out the pin connecting the radius rod hanger and the lift shaft arm. The link block is secured in the center of the link by means of the two blocks shown, one placed below and the other above the link block and securely wedged in position.

With the link block secured in the center of the link, care must be taken in making a stop that the main pin on the lame side is not on either quarter; as, in this case, the lap and lead lever would be in a perpendicular position, as shown in the illustration, and the valve would be central on the seat; and, as the pin on the other side would be on the dead center, it would be impossible to move the engine.

In some arrangements of the Walschaert valve gear, the radius rod is directly connected to the lift shaft arm by means of a slip block or crosshead. It is common practice

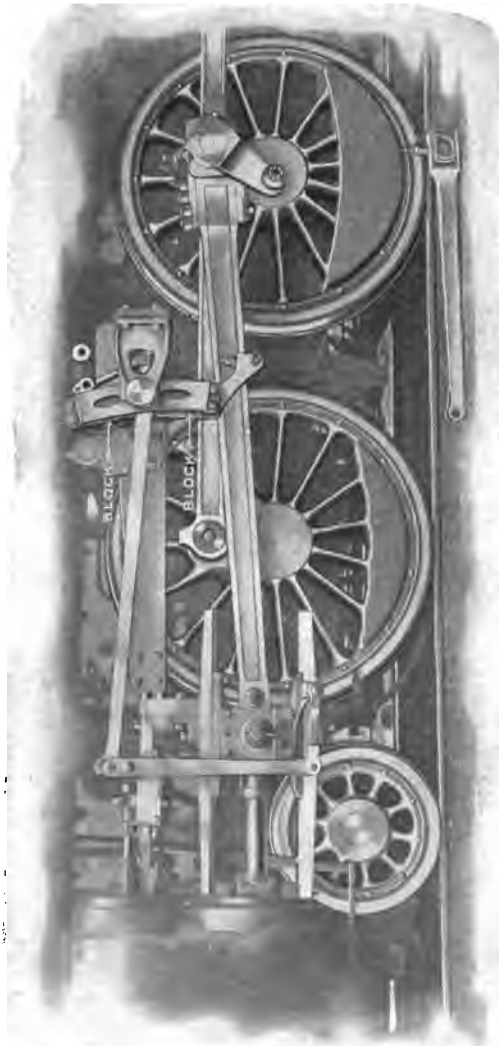

Fig. 141.

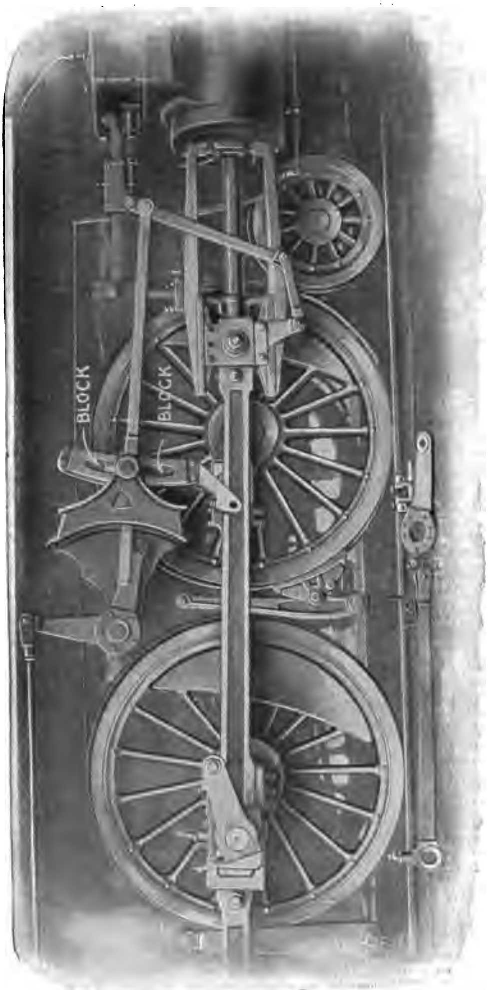

Fig. 142.

in such cases to make the lift shaft arm in two pieces so that the radius rod may be easily disconnected from it, as shown in Fig. 142. Remove the outer section of the lift shaft arm, take off the cap of the slip block, lift out the end of the radius rod and remove the slip block. The parts that it is necessary to take down are shown in Fig. 142. The link block is secured in the center of the link in the same way as in the previous case.

Covering the Ports. So far, we have not considered any accidents which would require blocking the valve to cover the ports. In all cases where this is necessary, if the engine has no relief valves in the cylinder heads to remove, it is good practice to take down the main rod on the disabled side.

Suppose, for instance, the main rod was broken, or the piston rod bent, or a cylinder head knocked out. In any of these cases, if the valve has inside admission and there are no relief valves in the cylinder heads, the engine may be disconnected and blocked, as shown in Fig. 143. Disconnect the front of the radius rod from the lap and lead lever and suspend it clear of the latter by means of a wire or chain from some convenient support. Secure the valve to cover the ports. This can usually be done by means of the set screw provided in the valve stem crosshead for this purpose; but, if there is no such set screw, the valve stem crosshead may be blocked. Take down the main rod and block the crosshead at the back end of the guides, as shown. With the valve motion disconnected in this way, the reverse lever is free to operate the other side and the engine can be run in on one side. If the crosshead arm, lap and lead lever connector, or lap and lead lever is broken, the engine might be blocked in the same way as illustrated in Fig. 143; except that, of course, such of the broken parts should be removed as would in any way interfere with the running of the engine.

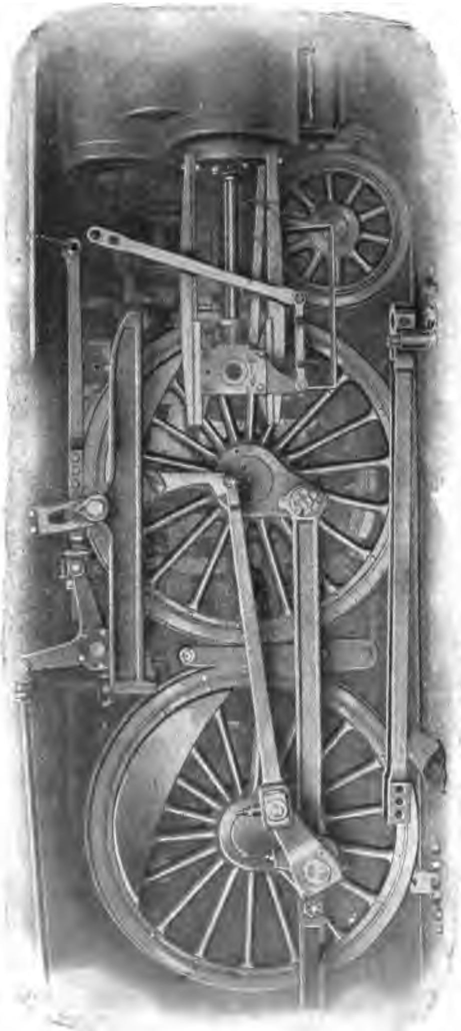

Fig. 143.

Fig. 144.

If the valves have outside admission and there are no relief valves in the cylinder heads, in cases where it is necessary to secure the valve to cover the ports such as have been

considered, the engine might be disconnected as shown in Fig. 144. Disconnect the radius rod from the lap and lead lever and take down the latter; as, otherwise, the front end of the radius rod would strike the lever as the radius rod moves back and forth to the motion of the link. Suspend the front end of the radius rod from the valve stem crosshead guide, using for this purpose a wire or chain (the fire door chain if no other is at hand). Secure the valve to cover the ports and take down the main rod and block the crosshead at the back end of the guide.

If the engine has cylinder relief valves and the main rod and piston on the disabled side are in condition to run, the main rod may be left up when the valve is secured to cover the ports. In that event, remove the relief valves from the cylinder heads to relieve compression and also permit of lubricating the cylinder.

Broken Lap and Lead Lever, Lap and Lead Lever Connector, or Crosshead Arm. Suppose, for instance, the lap and lead lever, lap and lead lever connector, or crosshead arm were broken; an engine with inside admission valves and relief valves in the cylinder heads could be blocked, as shown in Fig. 145. Disconnect the radius rod from the lap and lead lever and suspend it clear of the latter, as shown. Secure the valves to cover the ports. Tie the lower end of the lap and lead lever ahead by means of a rope secured to the cylinder cocks. Take out the relief valves, as previously recommended. The engine can then be run in on one side.

If the valves were outside admission, under the same conditions as assumed in the case illustrated in Fig. 145, the main rod could be left up and the engine disconnected in the same way; except that the lap and lead lever would have to be taken down in order to clear the radius rod.

We have not attempted to enumerate all the accidents

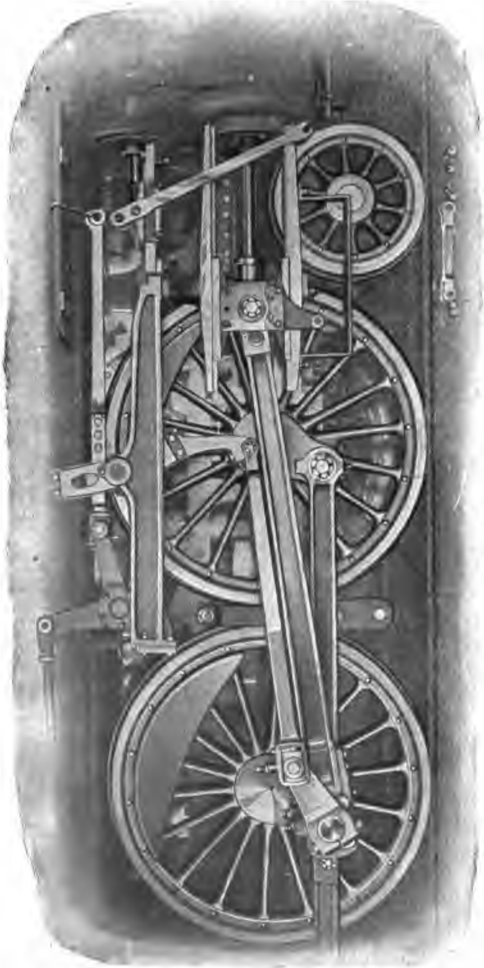

Fig. 145.

that might occur on the road; but we trust that the explanation of what may be done in the cases considered will assist the engineer to meet any troubles that might possibly happen to the Walschaert valve motion.

SUPERHEATED STEAM.

During the past few years many tests have been made with devices known as the "superheaters," which are attachments to the locomotive designed to reduce cylinder condensation by the superheating of the steam. It is claimed that this superheating results in economy of water consumption and of fuel.

The following description applies to what is known as the "Schenectady" superheater for locomotives.

It is claimed that this type of superheater overcomes the objectionable features of previous types, among

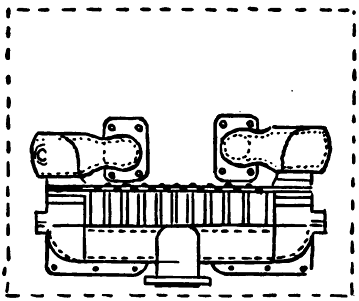

Fig. 146.

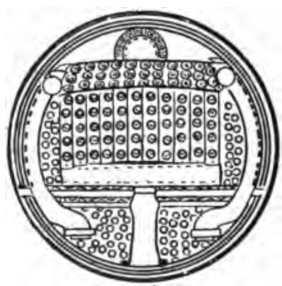

Fig. 147.

which have been the use of bent tubes and the necessity of disconnecting the whole superheater in order to gain access to leaky boiler tubes.

A feature in the construction of this superheater is the T-pipe, the regular conventional T-pipe being replaced by one of the special design, shown in Figs. 146, 147 and 148. This T-pipe is subdivided into two compartments by a horizontal partition, and extends nearly across the smoke-box, so that steam entering the T-pipe from the dry pipe is admitted to the upper compartment only. To the front side of the T-pipes are attached

eleven header castings (Fig. 147), the joints being made with copper wire gaskets.

Each header casting is also subdivided into two compartments, in this case by a vertical partition, and five pipes or flues of one and one-sixteenth inch outside diameter are inserted through holes in the front wall of each header. These one and one-sixteenth inch tubes are expanded into special plugs, which are firmly screwed into the vertical partition wall, and the five tubes are enclosed by five one and three-fourths inch tubes, which are expanded into the rear wall of the header casting in the usual way. Each nest of two tubes is encased by a regular three-inch boiler tube, which is expanded into the front and back tube sheets in the usual manner. The back end of each one and one-sixteenth inch tube is left open, the back end of each one and three-fourths inch tube is closed, and the back ends of both tubes are located at a point about thirty-six inches forward from the back flue sheet. The detail arrangement and grouping of three flues are shown in Fig. 148. The back end of the one and three-fourths inch tube is closed by welding, and the tail so formed as to support this tube in the upper part of the three-inch tube, thus leaving a clear space below. Fig. 149 shows that the one end one-sixteenth inch tubes are concentric, with the one and three-fourths inch tubes at their back ends, but the one and one-sixteenth inch tubes are allowed to drop and rest on the bottom of the one and three-fourths inch tubes.

Steam from the dry pipe enters the upper compartment of the T-pipe and thence enters the forward compartments of the eleven header castings, then passes back through each of the fifty-five one and one-sixteenth inch tubes; thence forward through the annular space between the one and one-sixteenth inch tubes and the one and three-fourths inch tubes to the rear compartments of

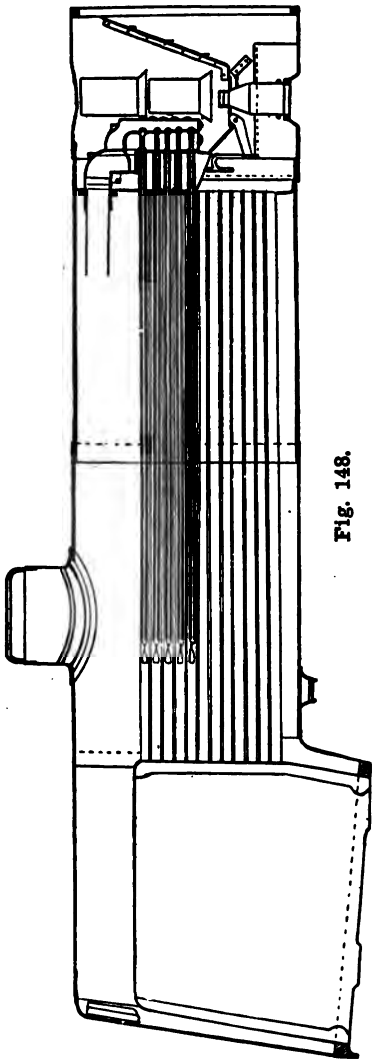

Fig. 148.

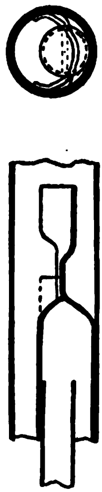

Fig. 149.

each of the eleven header castings, thence into the lower compartment of the T-pipe, thence by the right and left steam-pipes to the cylinders. In passing forward through the one and three-fourths inch tubes the steam is superheated by the products of combustion passing through the three-inch tubes.

In this particular design fifty-five three-inch tubes are inserted in the upper part of the flue sheets, thus displacing as many of the regular smaller tubes as would occupy the same space. The arrangement of the flues is shown in Figs. 148 and 149.

In applying the superheater to a locomotive it is necessary to provide some means by which the superheater tubes shall be protected from excessive heat when steam is not being passed through them. In this design it is accomplished by means of an automatic damper. When steam is admitted to the steam-chests, the piston of the automatic damper cylinder is forced downward and the damper is held open. When the throttle is closed the vertical spring immediately back of the automatic damper cylinder brings the damper to its closed position, and heat is not drawn through the three-inch tubes when the engine is not using steam. In this way the superheater tubes are effectively prevented from being overheated. In introducing the group of three-inch tubes and applying the superheater, the heating surface is slightly reduced, but the effect is more than offset by the economical results obtained by the superheating process.

When the superheated steam is used great care must be taken regarding the lubrication of the cylinders. Forced feed is usually used for this purpose instead of the gravity feed.

THE PYLE NATIONAL ELECTRIC HEADLIGHT.

Electricity may well be called the youngest of the sciences. It is impossible to define it. All that is known is that it is a certain intangible something, having neither form, substance nor weight, yet pervading all bodies. Its use and transformation into power are, however, governed by laws well known to the electrical engineer and scientist of the present age.

The high speeds at which modern trains are operated requires, in the interests of safety, the use of a headlight of sufficient illuminating power to throw a shaft of light far enough in advance of the locomotive, for the engineman to observe any obstruction or irregularity of the track in time to bring his train to a stop and avoid an accident. For this reason the qualities essential to the light are brilliancy and penetration.

Electricity fulfills the required conditions better than any other illuminant and is coming into more general use for headlight purposes. At the present time many high speed passenger locomotives are equipped with electric headlights. A knowledge of their use and operation will, therefore, be of benefit to every engineman.

The electric headlight, complete, consists of an engine and dynamo, and an arc lamp.

List of Parts. Engine and Dynamo.

1	Main Casting, 4 rows buckets	3	Engine Cap
		5	Box Yoke
2	Wheel, 5 rows buckets	6	Oil Cover, outside
		6½	Oil Cover, inside
2½	Wheel, 3 rows buckets	7	Pole Pieces
		8	End Thrust

9 Brass Yoke
10 Top Brush Holder
11 Bottom Brush Holder
12 Commutator
12½ Armature Spider
13 Commutator Ring
14 Dynamo Door
14½ Name Plate
15 Commutator Nut
16 Outside Washer
17 Long Bushing
18 Short Bushing
20 Stuffing-Box
21 Gland Nut
22½ Oil Ring
25 Top Field Washer
26 Bottom Field Washer
27 Dynamo Feet, old style
28 Binding Post, large hole
28½ Binding Post Nut
29 Binding Post, small hole
30 Governor Weight Clamp
30½ Governor Saddle Screw
31 Governor Weight
32 Spring Clamp
33 Cast-iron Washer
34 Connecting Link
35 Governor Stand
36 Cross-Arm
37 Center Piece
38 Bronze Plunger
39 Graphite Ring
41½ Governor Springs
42 Cap Spring
45 Armature Lock Screw
46 Cap Screw
47 Cap Screw
68 Binding Post Screw
97 Insulation Washer
97½ Insulation
101 Main Casting
105 Dynamo Foot
110 Brush Spring Adjusting Screw
111 Connecting Screw for Inc. Wire
112 Connecting Screw for Upper Field
113 Brush Spring
114 Brush Clamp Spring
115 Insulating Bushing
116 Brush Clamp Adjusting Screw
117 Governor Spring
118 Oil Cover Set-Screw
123 Top Field Cover
124 Main Shaft
152 Top Field, complete
152½ Bottom Field, complete
155 Armature

THE TURBINE ENGINE.

The engine, known as the Pyle Compound Steam Turbine, furnishes the mechanical power that operates the dynamo, and thus generates the electric current. It

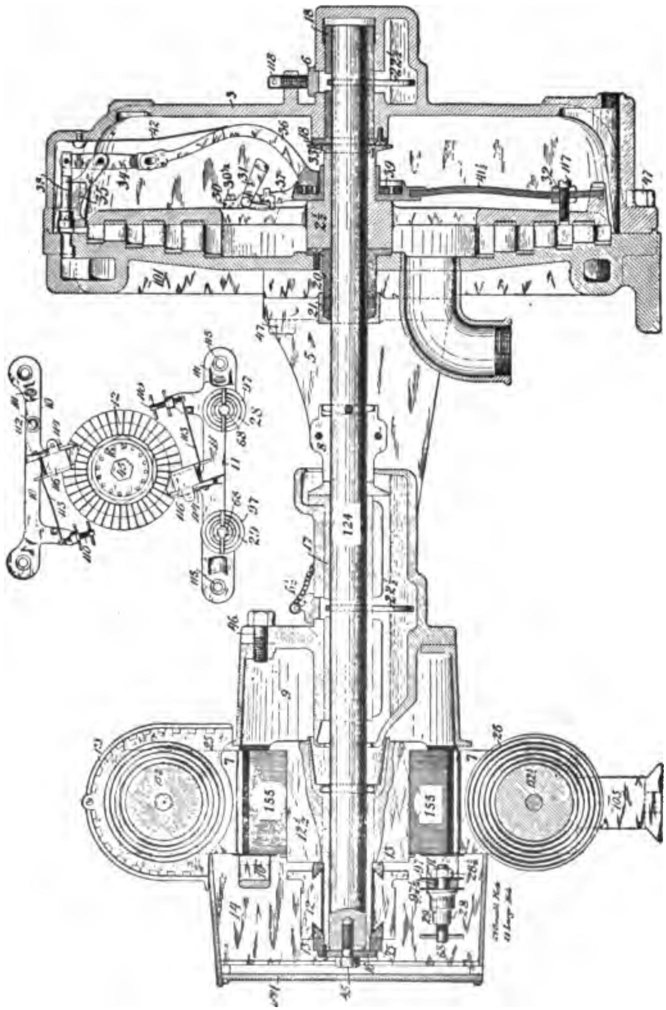

Fig. 150.

consists of a main casting, having three rows of exhaust or receiving buckets, the turbine wheel with its three rows of buckets, or paddles, the governor and the engine cap or head.

Steam Buckets. The buckets of the turbine wheel are all cast solid within the wheel and fit in a recess in the main casting and just over or above the stationary exhaust or receiving buckets (Fig. 150). The pressure of the steam against the buckets in the wheel is similar to that of water against the blades or paddles of a water wheel.

Steam Passages. Fig. 151 shows a vertical section cut through the main casting 101 of the wheel 2½, from which a good idea of the passage of steam may be obtained. The steam enters at A, passes through ports *f* in governor stand 35 (Fig. 150), and is directed against the first row, *a,* of buckets, and the wheel moves forward. This movement allows the steam to pass out through the bottomless buckets of the wheel into the series of exhaust

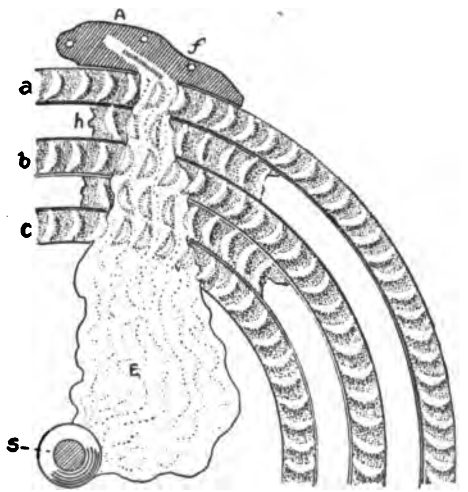

Fig. 151.

passages *h,* in main casting 101, the travel of the steam being reversed in a measure. These exhaust passages are so shaped that the movement of the steam is again changed to a forward direction and discharged into the second row, *b,* of buckets, and so on until the final exhaust is made to central chamber E, and thence to the atmosphere.

No internal lubrication is required, as this engine has no reciprocating parts, is perfectly balanced and has no wearing surfaces.

Governor. A governor similar in design to the old style centrifugal governor, which has two heavy balls carried by the two arms, used on stationary engines, is used to control the flow of steam to the turbine wheel

The governor weights 31 (Fig. 150), four in number, are simple bell cranks and the connection to the wheel is made by clamp 30. The shorter end of weight 31 extends beneath center piece 37 and is held down in this position by four sets of springs 41½. Resting within center piece 37 is a bronze ring 39. The ring is known as the graphite ring, and is drilled full of holes, and these holes are then filled with graphite. Its purpose is to lubricate the face of the cross-arm. Both the cross-arm and the ring will wear for an indefinite period.

Fig. 152 shows a view of cross-arm 36, connecting link 34, governor stand 35, and bronze plungers 38. There are two governor stands, two connecting links, and the cross-arm has two ends instead of one. Attached to the ends of cross-arm 36 are the connecting links, and at the other ends of these links are the governor valves or bronze plungers 38. The connecting links are suspended by the governor stands 35, the governor stands are secured to the main casting 101 (Fig. 150), and the governor valves or plungers 38 work within the governor stands.

As the turbine wheel 2½ increases its speed, the

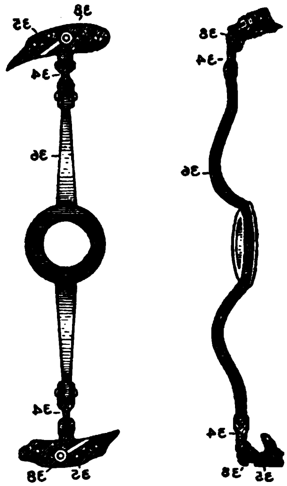

Fig. 152.

governor weights revolve more rapidly about the vertical axis of the shaft, and tend to move outward. In doing so they raise center piece 37, which pushes cross-arm 36 farther away from the wheel. The ends of the cross-arm being attached to one of the two ends of the connecting links 34, carries these ends of the two connecting links out with it and away from the wheel. The link being fulcrumed in the governor stand, this movement will force the governor plungers in toward the seat, thus diminishing the supply of steam to the turbine wheel and preventing the wheel from attaining an excessive speed.

When the centrifugal force of the wheel is great enough to carry the ends of the governor weights 31 out and at right angles to the face of the turbine wheel, the governor plungers or valves 38 should then be on the seat of the steam passage to the turbine wheel. If the governor weights are allowed to travel beyond right angle position, the governor will not control the speed,

and it will then be necessary to throttle the steam, or the speed of the armature will become so high that an electromotive force will be built up to an extent that will soon destroy the copper electrode in the lamp.

The electromotive force or voltage is built up by the revolving of the armature; the higher the speed of the armature, the greater the electromotive force or voltage.

Effects of Varying Loads on Engine. The load thrown upon the engine by the dynamo varies according to the length of the arc at the lamp; the shorter the arc, the greater the load. When the arc is short the throttle openings must be large enough to admit a sufficient volume of steam to the turbine wheel to maintain the speed of the armature at a certain point. As the arc grows longer, due to the burning away of the carbon, the load on the engine becomes lighter, and if the steam supply is not diminished at this particular time, the turbine and armature will soon attain a speed at which the voltage will be built up so high that the copper electrode in the lamp will be fused. Or, if the load should suddenly be taken off the engine by one of the main wires breaking, or the carbon sticking up in the clutch of the lamp, there would be danger of the turbine wheel attaining a velocity at which it might be thrown to pieces by centrifugal force.

CENTRIFUGAL BRAKE.

List of Parts.

133	Brake Shoe	135-b	Brake Saddle Screw, large
133-a	Brake Shoe Roller	136	Adjusting Nut
134	Brake Shoe Spring		
135	Brake Saddle		

To prevent any possibility of accidents being caused by varying loads on the engine a centrifugal brake is attached to the turbine wheel. Fig. 153 shows a sec-

tional view of this brake. It is placed on the back side of the wheel 2½, and is so adjusted that it acts at a speed of about 150 revolutions per minute greater than that at which the governor acts. When the wheel attains a velocity great enough to overcome the tension of spring 134, the brake shoes 133 travel out until they come in contact with the wall of the main casting 101, and so prevent the speed of the turbine wheel from

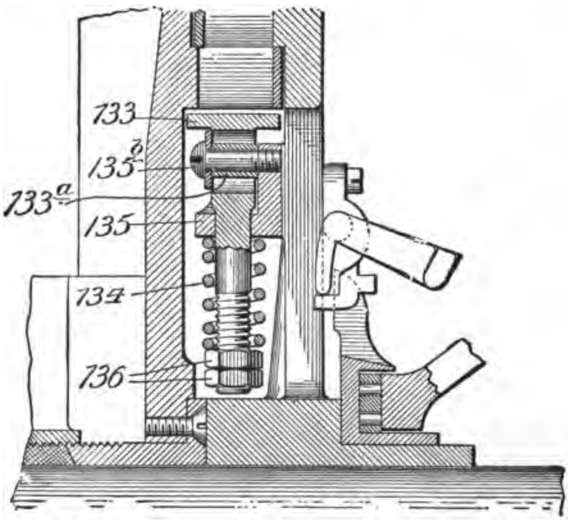

Fig. 153.

exceeding a certain limit. The application of this brake began with the equipment, bearing the manufacturer's serial number 2600, and it will not be found, nor can it be applied to equipments with a lower serial number than this.

To adjust the centrifugal brake, the armature, engine cap and governor should be removed, and the wheel and shaft pulled out, giving free access to the brake. To decrease the speed, all nuts should be turned to the left,

and to increase speed, all nuts should be turned to the right. One-half turn of the nuts will change the speed at which the brake will act, 150 revolutions per minute. However, it is seldom necessary to readjust the brake if correct travel of the governor valves is maintained.

Governor Plungers and Valves. The face of the governor plungers 38 will eventually become cut and worn by the passage of the steam, and when this condition exists the supply of steam to the wheel will not be diminished when maximum speed is attained, and the electromotive force will be built up, causing the electrode in the lamp to fuse. Valves that have become badly worn must be faced off. When this has been done, and the governor weights are drawn at right angles to the face of the turbine wheel, the governor plungers 38 will not rest on the seat of the steam-supply.

To cause the governor valves to seat firmly when the governor weights are drawn to right angles with the face of the turbine wheel, the ends of cross-arm 36 should be bent back and away from the face of the wheel. To determine how much the arms should be bent, the governor weights should be pulled out by hand until they are straight, or at right angles to the face of the wheel and held in this position. The plunger valve 38 should be moved in by hand until it seats. A rule should then be placed on the end of governor stand 35, the valve pulled back and the amount of travel noted. Half of the measurement shown is the distance the ends of the cross-arm 36 should be bent away from the face of the wheel to bring the plungers or valves on their seat, which will give correct travel.

Whenever it is necessary to remove the engine cap for the purpose of making any changes in the governor, the end thrust or play should always be adjusted before the engine cap is removed, for if the cross-arm is bent to

change the travel of the valves, and the end thrust is afterward taken up, the valves will be carried in almost, if not entirely, to the seat of the steam supply, and will be held in that position until the engine cap is removed, and the cross-arm again adjusted to conform to the position of the wheel.

Bad water, or foaming of the engine, may at times cause the governor valves to stick. If one of the valves sticks open when the load is on, and the dynamo is running at a maximum speed, it is a certainty that the point of the copper electrode will be fused. The fusing of the electrode can be detected by a shaft of green light thrown on the track, instead of the usual white light, for when copper is fused a green light is given off. The speed of the turbine should be reduced by partly closing the throttle as soon as this green light is observed.

If one of the valves 38 sticks shut, it can be detected by the light becoming dim, and if the steam pressure in the boiler drops very low, the light will go out, for the reason that enough steam to pull the load will not be admitted through the one open port. This would be particularly the case with equipments applied to locomotives of low boiler pressure.

The sticking of the governor valves is usually caused by lime or scale in the pipe. They can often be released immediately by jarring casting 101 at the point where steam is introduced to the valves. In almost every case it will be found that it is the top valve which sticks.

It is unnecessary to lubricate the turbine wheel or the governor plungers, as there is no frictional wear. Before starting on each trip the plug in the top of engine casting 101 should be removed, however, and a little coal oil or engine oil introduced at this point. When the steam is turned on, this oil will be carried against the governor plungers, and will cut away any scale

that may have started to form on the parts, thus preventing the valves from sticking.

The speed at which the armature revolves determines the voltage, and the efficiency of the arc. As the turbine wheel is responsible for the speed of the armature, it is evident that anything that offers an easier avenue for the passage of steam to the atmosphere than its regular course through the turbine wheel, will prevent the production of a good light.

As the steam is delivered to the turbine wheel at diametrically opposite points, the wear to the bushing in engine cap 3 should be uniform.

The kinetic energy attained by the wheel will cause it to revolve for some time after the steam is shut off, and after it comes to a stop the weight of the wheel will rest on the bottom of the bushing. The governor stand 35, which directs the steam against the buckets of the turbine wheel, is suspended to main casting 101, and if bearing 18 in the engine cap becomes worn from lack of lubrication, the turbine wheel will wear off the edge of the lower governor stand and drop down and away from the top of governor stand so far that the steam will pass around on either side of the wheel to exhaust E (Fig. 151).

When these conditions exist, a new short bushing should be used to replace the worn one in the engine cap 3, and a new governor stand 35 and a new stuffing-box bearing 20 put in.

The above conditions will be apparent by a failure to get up speed while the light is burning. A governor plunger stuck closed will, however, cause the same trouble. When the engine cap is removed to locate the trouble, it can readily be noted whether one of the plungers is stuck, or the wheel is down too far away

from the governor stand to direct the steam against the buckets.

MAINTENANCE OF THE TURBINE ENGINE.

When a turbine engine has been in service for some time, the bearings neglected and not properly lubricated, the bushings not renewed and the end thrust maintained too close, the wheel will be carried out and away from main casting 101. On account of the close adjustment of the end thrust the steam will be delivered against the back edge of the buckets of the turbine wheel, instead of to the center, and will pass around on the back side of the wheel to the exhaust E. This will render it impossible to get up speed with the light burning.

The source of the trouble can be located by removing the engine cap, and a new cast-iron washer 33 and a new bushing in engine cap 3 will be required. If there are no new parts on hand, temporary repairs can be made by loosening the screws in end thrust casting 8, tapping the end thrust casting on the left side (facing turbine) until it is loose on the shaft, moving the wheel as far in toward the main casting as it will go and placing a metal washer between the flange of the bushing 18 and cast-iron washer 33. Care should be taken that the washer used is only of sufficient thickness to take up the lost motion between the bushing flange and the cast-iron washer, and to maintain the wheel in such a position that the steam will be delivered directly against the center of the buckets. If this washer is too thick it will be impossible to replace the engine cap. The flange wear is very slight, and it is seldom necessary to renew the bushing on this account.

It will thus be seen that there are several defects which may exist in the turbine engine which will result in lowering the speed of the dynamo and producing

a poor light, and other conditions that will permit the speed of the armature to become too high, building up a voltage that will cause fusing of the copper electrode. The speed of the turbine is not, however, influenced to any marked extent by changing the tension of regulating spring 41½ of the governor. As already explained the duty of the governor springs is to offer the proper resistance to the movement of the governor weights, and the purpose of the governor weights is to control the amount of steam delivered to the turbine wheel at different speeds, the position of the governor weights being determined by the centrifugal force exerted by the wheel. If it is difficult to attain the proper speed or to maintain the speed with the slight fluctuations of boiler pressure, the engine cap 3 should be removed and a thorough inspection made for the troubles already named, before the tension of the governor springs is changed. One-half turn of all governor screws 117 will change the speed at which the governor acts 100 revolutions per minute. To increase the speed of the turbine and armature, the screws should be turned to the right, and to decrease speed they should be turned to the left.

End Thrust. End thrust is given to this device in order to prevent scratching or grooving the commutator. All carbon brushes are not entirely free from hard spots or grit. If it were not for the shifting of the brushes, the hard spots in them would soon wear the commutator down unevenly in such a manner that it would become useless, and the dynamo would refuse to build up.

There should be not less than one thirty-second of an inch end thrust in the shaft when the engine is cold. To adjust the end thrust, the screws in end thrust casting 8 should be loosened, and one hand placed on the commutator, so that, by moving in and out on it, the amount of the movement can be judged. By tapping casting 8

lightly on the left side (facing the dynamo), the end movement of the shaft will be taken up. After the end thrust has been adjusted, the screws should be tightened up. If the screws become loose as the shaft revolves to the right (when facing the dynamo), and the end thrust is reduced by moving the casting in the opposite direction, the shaft will be carried in until the friction between the flange of bushing 18 and cast-iron washer 33 becomes so great that the engine will be stalled. This condition can be detected by the escape of a large amount of steam at the exhaust and the refusal of the engine to move, but it can quickly be remedied by tapping the casting to the right until it releases the shaft. The end movement should then be adjusted in the manner already explained, and the engine will be ready for service.

It will be noted that cast-iron washer 33 has a small dowel attached to its outer side, which fits into a small hole in the hub of the turbine wheel, and is for the purpose of holding the washer in a stationary position. All wear of the washer comes on its face, which is in contact with the flange of bushing 18. If this dowel is broken, the washer will be carried around by the rotation of the shaft, and its thin and narrow outer surface will be worn away rapidly, thus increasing the end thrust beyond the point desired. Whenever engine cap 3 is removed for repairs or inspection, this cast-iron washer should be closely inspected, and if the dowel is broken off it should at once be renewed. Otherwise, in a short time the steam will be delivered to the back edge of the buckets of the turbine wheel, and it will be difficult to maintain the speed of the turbine and armature at a point that will produce a good light, with the fluctuations of boiler pressure met with under ordinary circumstances.

LUBRICATION.

While the bearings of this device require comparatively little lubrication, it should not be neglected, for nothing will increase the cost of maintenance quicker than the failure to furnish a proper supply of lubricant at the proper time.

Oil Rings. The oil rings 22½ are suspended by and around the shaft and into the oil cellars at bearings 17 and 18. Bearing 17 has nearly twice the length of bearing 18. On account of the action of the steam passing out of exhaust chamber E and the condensation in the box, it is necessary to introduce a little oil in the cellar of bearing 18 each trip.

Before filling the oil cellar the drain cock should be opened, the water of condensation drained off, and the drain cock closed. Enough valve oil should be introduced so that loose ring 22½ suspended by the shaft will touch the oil in the cellar; about three or four tablespoonfuls will ordinarily be sufficient. On account of the heat of the engine it is not practicable to use an oil with less body than valve oil for this purpose.

In lubricating bearing 17, however, the best results will be obtained by the use of black or engine oil, as the loose ring 22½ carries a small quantity of lubricant up during each revolution and deposits it on the shaft, from whence it passes through grooves in the bushings to the bearing proper. An oil with too heavy a body would be too thick to feed through these grooves and would drop back into the cellar, the bearings would not receive a proper supply of lubricant and the result would be a cut shaft and bushing. The same good judgment should be used by the engineman in oiling these bearings as in filling the oil cups on the locomotive.

The supply of oil in the cellars should be just sufficient for the rings 22½ to touch it. If the inside cellar is filled

too full, the oil will be thrown out at the end by the motion of the locomotive, and may find its way to the armature and destroy the insulation of the coils.

A quarter-inch hole is drilled in the side of the box yoke to act as an overflow.

This bearing should be examined each trip, but it is seldom necessary to oil it oftener than once or twice a week.

Particular attention should be paid to stuffing-box 20, which should be packed with lamp wicking and kept tight enough to prevent blowing. The packing in this box is only required to withstand the exhaust pressure, which is very low, yet if steam is allowed to blow at this point it will follow along the shaft and blow off the oil that has been deposited there by the loose ring, not only preventing the bearing from receiving its lubrication, but also blowing the oil into the coils of the armature. No doubt there are many enginemen who lubricate this bearing most faithfully, yet pay little attention to the steam blowing from the stuffing-box, and fail to understand why the bushing wears so fast.

The shaft revolves thirty times each second when running at maximum speed, and if the bearings are not properly lubricated the shaft and bearing will soon be ruined. If properly lubricated, however, the wear will take place entirely in the boxes. The bearings can be easily and quickly removed without removing the equipment from the locomotive.

THE DYNAMO.

The dynamo is simple in form, consisting of two main parts, an armature, which in revolving between the two pole pieces 7 (Fig. 150), induces an electromotive force in the copper wires wound upon it, and a field magnet, 152 and 152½, whose function is to produce a field of magnetic lines to be cut by the armature wires as they revolve.

The Armature. The armature is connected directly

to the engine shaft, and revolves with it. The electrical balance is absolute, and there should be no sparks seen at either of the two brushes.

The armature is held in place on the engine shaft by a single screw, which can easily be removed when necessary. The brush holders are fixed, and the brushes can be taken out and replaced without changing the tension of the springs.

This type of dynamo is dependent for its action in building up, upon the presence of what is known as residual magnetism in its field magnet.

The duties of the fields are to produce a magnetic field, which is accomplished by passing a current of electricity through their coils, but when the current no longer circulates through the coils, the magnetism disappears, with the exception of a very small flux, which is called residual magnetism. This residual magnetism is responsible for the weak magnetic field, which is always present between the pole pieces and the field pieces.

When steam is admitted to the turbine wheel, the armature, which is attached to the engine shaft, and revolves in the armature chamber, cuts the few lines of force contained in this magnetic field, and a small electromotive force is set up in the armature. The ends of the field coils being connected to the brushes, and the latter being in contact with the commutator, a closed circuit is formed through the field coils. This small electromotive force sends the current through the exciting coils, which instantly increase the strength of field magnet 152 and 152½, and an increased electromotive force is induced in the armature. This results in a stronger current being sent through the exciting coils and the increased magnetism induces an increased electromotive force in the armature. This process of building up continues until at a certain speed of the armature the voltage attains a maximum value, beyond

which it cannot be increased without increasing the speed. The duties of the armature are to concentrate and direct the flow of current, and the voltage is determined by the speed.

The Commutator. The function of the commutator is to collect the currents produced by the cutting of the lines of force. It consists of a combination of copper bars, separated by insulation, forming a cylinder around the aramture shaft, and connected to the armature wires. The brushes are pressed against the commutator by springs 113 (Fig. 150), and make a sliding contact with it. The brushes must have a certain amount of flexibility in order to adjust themselves to any irregularities in the surface of the commutator, and also to avoid scratching and cutting the commutator bars.

Production of the Electric Spark or Light. The electric spark or light is produced by placing opposition or resistance in the path of an electric current. When a current of electricity in passing through its conductor reaches a point where it cannot pass easily, as, for example, in the incandescent lamp, wherein a large wire is suddenly reduced to a small one, heat and light are at once produced.

A spark or continuous arc is produced by bringing two points of carbon in contact with one another. When the current is established, the carbons are drawn apart a short distance by the mechanism of the lamp, and an electric flame, known as the arc, is produced. This arc cannot be produced if the carbon points remain in contact, and it will not be continuous if the points of the two carbons are separated too far.

Brush Holders and Brushes. As the current is generated in the armature wires, collected at the commutator, and flows from the bars of the latter into the brushes and thence through the circuit, it is evident that the contact

between the metallic bars of the commutator and the brushes must be smooth and true, and that the brushes must bear upon the commutator with the proper pressure.

If the pressure is too light the brushes will jump and spark, and if it is too heavy, the brushes will cut and scratch the commutator. Correct pressure is attained when the brushes collect the full strength of the current without sparking, while the pressure upon the commutator is just sufficient to overcome any vibration caused by the jar of the locomotive when in motion.

With the old style brush holder the adjustment is made by means of a brush spring 113 and adjustment screw 110. With this style of holder it is necessary to give daily attention to the spring tension, which should be tightened only to prevent sparking.

On all the latest machines the brush holders are provided with a fixed tension spring, which maintains a predetermined pressure of the brush against the commutator at all times. This spring cannot work loose nor can its tension be changed by the engineman. With this brush holder there should be no commutator troubles if the latter is kept free from dirt.

When a brush is not bearing with sufficient pressure against the commutator bars, it is called improper contact, and will result in sparking at the brushes. This, however, is not caused by too great a tension of the spring.

Applying Brushes. When it becomes necessary to apply a set of new brushes, or to tune up the old ones, a piece of No. "o" sandpaper should be placed on the commutator with the rough side against the brush. The paper should be pulled through and under the brush in the direction of the rotation of the armature, and this should be continued until the brush is fitted to and has the same contour as the commutator (Fig. 154). The reason for fitting the brush in this manner is, that this will pull it over

against the brush holder in the same position in which it is carried when the dynamo is in operation, resulting in a perfect bearing.

Fig. 154.

Particular attention was necessary with the old style brush holders to see that they were always clean, as when dirty they were liable to cause the brush to stick, which would result in sparking.

When the brushes are worn to a smooth and polished bearing and the commutator takes on a high, dark cherry polish, the contact is perfect and there will be practically no wear on them.

COMMUTATOR AND BRUSH DEFECTS.

The commutator is a vital part of a dynamo, and, together with the brushes, requires constant attention to keep it in a satisfactory working condition, and it must be mechanically clean to run without sparking. Spots of paint

or dirt may be on it and get between the brushes and the copper bars. This will prevent a perfect contact at one point and sparking will result. Close attention must be given it, and sparking of the brushes must be avoided as far as possible, as this causes the edges of the copper bars to fuse. The fusing action roughens it, which renders commutation still more difficult. Trouble of this kind once started grows rapidly worse until it is necessary to remove the armature from the shaft and true up the commutator in a lathe.

Another cause of improper contact and sparking is the projection of the mica insulation above the surface of the commutator, preventing the brushes from touching the metallic parts. The mica insulation is much harder than the brushes and copper bars, and consequently does not wear away as rapidly. After the machine has been run for some time, the copper bars will become worn and the insulation will project above them, causing improper contact and sparking.

To prevent the mica from causing improper contact, it should be kept dressed down about one sixty-fourth of an inch below the surface of the commutator. This can be done by means of a file, but a better method is to make a small scraper, and cut or scrape the mica down to the proper height. This method lessens the possibility of increasing the width of the grooves between the copper bars, which would be objectionable. These grooves soon fill up with dirt, carbon dust, etc., and, if not cleaned out occasionally, will result in a short circuit across the commutator.

The process of dressing down the mica insulation will raise a slight burr on the edges of the copper bars, which must be removed. This can be done by cutting a strip of No. "o" sandpaper about the width of the commutator surface, removing the brushes from their holders, starting

the dynamo, and holding the sandpaper by the ends, working it back and forth lengthwise of the commutator, covering the entire surface and continuing until its entire face is perfectly smooth (Fig. 154). The dynamo should then be stopped, the commutator wiped perfectly clean with a damp cloth or a piece of waste, and then rubbed dry with a clean cloth or waste. The surface of the commutator should be rubbed until it will not soil a white cloth. The bars should be rubbed lengthwise in order to remove any small particles of sand which may have become lodged in the grooves. If these particles are left undisturbed they will be thrown up and caught between the bars and brushes, when the dynamo is started, producing sparking.

Emery paper should never be used on the commutator, and sandpaper must not be used unless the surface is cut or scratched. As the commutator is the vital part of the dynamo and proper contact between the brushes and the commutator bars is necessary to insure satisfactory results, it is the duty of the engineman or inspector to see that the commutator is mechanically clean before starting the dynamo.

MAIN WIRES AND THEIR CONNECTIONS.

The wires that conduct the current to and from the lamp are connected to binding posts 28 and 29 on the bottom brush holder (Fig. 150). One of these posts, known as the positive binding post, has a large hole, in which is inserted the lead wire which conducts the current from the dynamo to the lamp. The other post, known as the negative binding post, has a smaller hole, in which the wire is inserted that conducts the return current to the dynamo, after it has passed through the lamp. The end of the wire which is connected to the positive binding post is doubled back, so that it will not enter the hole in the negative

binding post, preventing improper connection. Two binding posts similar to those at the dynamo are attached to the lamp. The positive post has a large hole and the negative a smaller one. The main wire from the positive post must be connected to the positive post at the lamp, and the main wire for the return current must be connected at both negative posts. This allows the current from the dynamo to pass first into and through the top carbon, which, resting on the electrode, allows the current to pass through the electrode and electrode holder, secured by clamp 53 (Fig. 155), and then into a wire which is attached to this clamp. This wire conducts the current into and through solenoid 65, and on to the negative binding post and thence through the return wire back to the dynamo, thus completing a circuit.

Open and Closed Circuits. A circuit is closed when it forms a continuous conducting path for the passage of an electric current, and open when a break occurs in the continuity of such path in such a manner that a current cannot flow.

The purpose of the insulation of the wires is to confine the flow of current to the conducting medium, or wire, and along a predetermined path. If this insulation becomes distorted or is destroyed, and the wires are brought in contact with one another, either directly or through the medium of some other conducting material, the current will not flow through the path of high resistance which leads through the lamp, but will follow the path of least resistance from one wire to the other, forming what is known as a short circuit, and resulting in a failure of the light.

If either of the brushes fails to touch the commutator, if one or both of the main wires are broken, if there is no carbon in the lamp, or the carbon does not touch the point of the copper electrode, there will be an open circuit.

It will be noted that there is a distinct difference between a short circuit and an open circuit. In a short circuit a complete circuit is formed, but with an open circuit no circuit is formed over which the current can flow.

THE LAMP.

List of Parts.

28	Binding Post, large hole
28½	Binding Post Nut
29	Binding Post, small hole
40	Reflector Clamp, bottom
40½	Reflector Clamp, top
41	Reflector Support
44	Clutch
49	Extension Base
50½	Lamp Base
51½	Lamp Column
52	Bottom, large clamp
53	Bottom small clamp
54	Hand Nut
55	Hand Washer
57	Top Bracket
58	Spring Tension Screw
58½	Spring Tension Nut
59	Top Lever
60	Small Lever
61-a	Dashpot
61-b	Dashpot Plunger
62	Magnet Insulation
63	Magnet Long Link
63½	Magnet Short Link
64	Magnet
65	Solenoid
68	Binding Post Screw
69	Top Lever Screw
74	Set-Screw
78-a	Clutch Rod Weight
78-b	Clutch Rod
79	Thumb Nut
81-a	Thumb Screw
87	Carbon Clamp, male
88	Carbon Clamp female
90	Magnet Yoke
91	Carbon Holder Spring
92-a	Top Clutch Spring
93	Tension Spring
96	Insulation Fibre
97	Insulation Washer
98	Vertical Adjusting Screw
99	Vertical Adjusting Nut
100	Upper Carbon Holder
102	Clutch Foot
102-a	Clutch Foot Rod
106	Electrode Support

107	Electrode Set-Screw	122	Clutch Weight Screw
108	Electrode Lock-Nut	200	Electrode Holder, complete
109	Copper Electrode	300	Top Carbon Holder, complete
120	Solenoid Screw		
121	Reflector Clamp Screw		

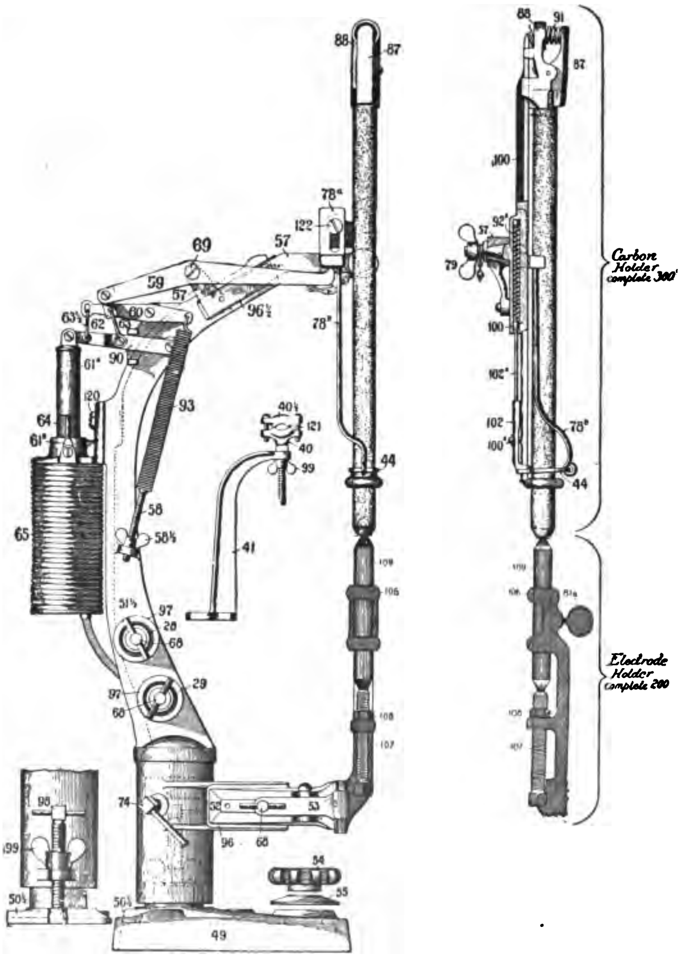

Fig. 155.

Carbon and Electrode (Fig. 155). The carbon through which the current first flows is called the positive carbon, and with a direct current, that is, when all the current generated by the dynamo flows through the wires in one direction, an arc or crater is formed in the positive carbon. The electric lamp, commonly used for street lighting and known as the "arc lamp," was so named because it was found that when a current was passed from one carbon point to another, an arc was formed in the positive carbon.

The temperature of the electric arc is about 7,000 degrees Fahrenheit. The melting point of copper is 1,996 Fahrenheit, yet, excepting under certain conditions, the copper electrode with its point of from one-sixteenth to three-sixteenths of an inch, which is exposed to the temperature of the arc, 7,000 degrees, will not fuse. This is due to the protective action of the carbon.

When the arc is produced between the carbon and the copper electrode, the carbon slowly burns away through oxidization, and small particles of it are torn away from its point and volatilized between the two points. A portion of these volatilized particles is deposited on the point of the copper electrode and the current flows through it to the electrode. These particles of carbon have a very high resistance and become intensely heated by the passage of the current, and as long as they deposit on the point of the electrode, the electrode will not fuse.

As previously explained, the speed at which the armature revolves determines the voltage or electromotive force, and this in turn determines the temperature of the arc. When the speed of the armature produces a voltage high enough to raise the temperature beyond a certain point, these small particles of carbon are dissipated before they reach the point of the copper electrode, and the electrode will melt or fuse, giving off a green light.

When the green light is observed, and there is nothing

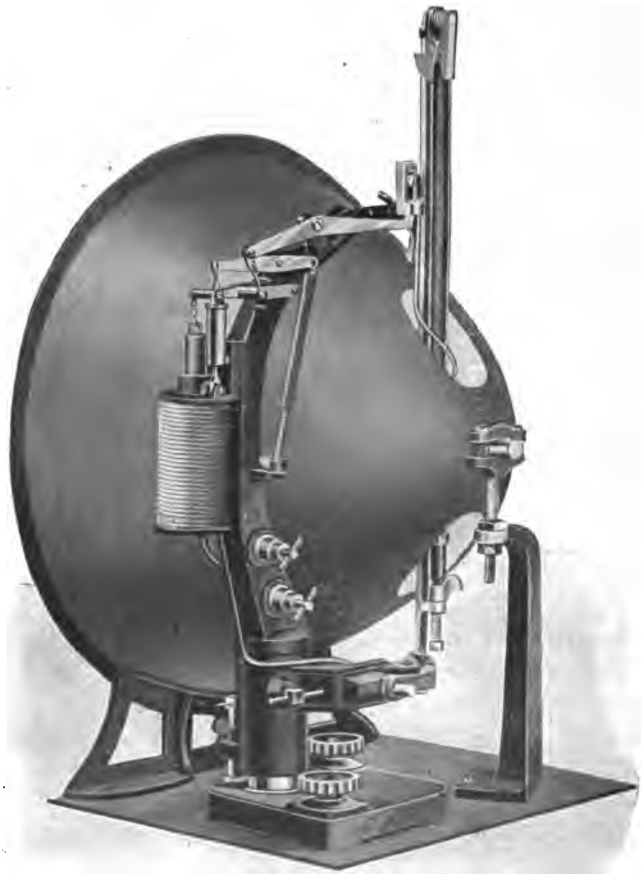

Fig. 156.

else so intensely green as a shaft of light thrown out by the headlight when the electrode is fusing, the speed of the dynamo should be reduced by throttling, and a report of the facts made upon arrival at the terminal.

If the wires are connected in such a manner that the

current can pass through the solenoid 65, and enter the copper electrode 109, and pass through the electrode and into the carbon, the usual course of the current will be reversed, and the copper electrode will be converted into the positive point. The arc is always created in the carbon point, which the current enters first. As copper will fuse at a temperature of less than 2,000 degrees Fahrenheit, and the temperature of the arc is 7,000 degrees Fahrenheit, the copper electrode would be rapidly destroyed if the wires were not changed at the binding posts in such a manner that the current would enter the lamp at the top, and flow down through the carbon.

It is customary with some manufacturers sending out wire to be used between the dynamo and lamp to put lead ferrules on the ends of the wire used to connect the two positive posts, so that there can be no possibility of error in making the connection.

An engineman should examine his wires carefully and see that the wire which is connected with the positive posts has ferrules on the ends, or if not, whether the ends are doubled back. If this is not the case, to prevent any possibility of future errors in connections, he should strip off the insulation far enough to permit the ends to be doubled back.

It is possible to ascertain whether the wires are correctly connected without waiting for the electrode to be destroyed, which will destroy the focus of the light to a considerable extent. The point of the positive carbon, which the current enters first, is always heated first, this being due to intensely high temperature of the arc. When the dynamo builds up, and the arc is produced, the point of the carbon will be brought to a white heat almost instantly, if the wires are properly connected. If, on the other hand, the carbon point is not brought to a white heat within a second or two, it indicates that the current is being delivered to the lamp at

the wrong binding post, and the wires should be changed.

If two carbons are used instead of one carbon and an electrode, the point of the positive carbon is the first to become heated. The wires in the lamp equipped with two carbons should, however, be so connected that the top carbon will always be the positive one.

This is essential, for the reason that the top or positive carbon burns away much faster than the lower or negative one. The positive carbon is about twelve inches long and the bottom carbon holder is so constructed that it will hold a carbon of about half that length. As the positive carbon burns away more than twice as quickly as the negative carbon, and is fed down by its own weight, the rate of feed being governed by the mechanism of the lamp, if the bottom one is converted into the positive one by the introduction of the current at the bottom of the lamp, it would soon be burned up. The top carbon would, however, continue to feed down, maintaining the same distance between the two points, and the intense heat of the arc would soon destroy the bottom carbon holder.

How the Light or Arc Is Produced. The electric light, or arc, is produced only when the proper amount of resistance is offered to the flow of an electric current, and this light is not produced by the burning of electricity. The electricity that is concentrated in the armature and passes to the lamp returns to the armature, but its pressure or voltage is dissipated in the arc produced at the lamp. If this were not the case, and if the carbon were held on the point of the electrode when the dynamo is in operation, the effect on the turbine would be similar to that which would be produced in the cylinder of a locomotive, if the steam after driving the piston to one end of the cylinder were unable to escape to the atmosphere.

This might be called a short circuit through the lamp, as there would be no resistance offered to the flow of

current. The circuit would be closed and the pressure or voltage could not be dissipated.

If the dynamo were run in this manner for any length of time the coils would become hot enough to char the insulation of the wires, and the current would leak through from layer to layer, producing what is called a burned out armature.

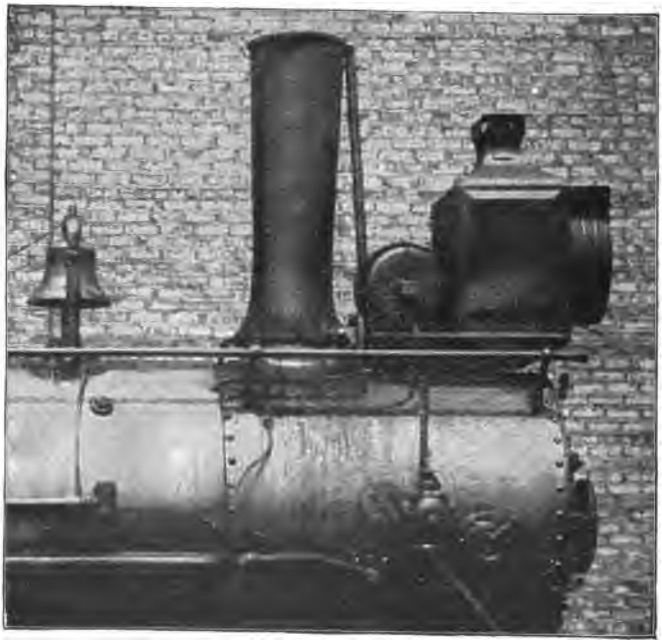

Fig. 157.

To form the arc and so produce the light, the carbons must be pulled apart a short distance. This is accomplished by means of solenoid 65, the coil on the lamp.

When an electric current flows through a coil of wire, this coil becomes an electromagnet. The solenoid is an electromagnet, and provides the automatic mechanism,

which feeds the carbon down as fast as it is consumed and maintains the arc at the proper length. The mechanism becomes weaker as the length of the arc increases, and when the arc reaches a certain length the magnet becomes weak enough to release the clutch, which allows the carbon to drop, through gravity, toward the electrode. Before the carbon can drop to the electrode the magnet is strengthened and the downward motion of the carbon is arrested.

When the dynamo is stopped for any considerable length of time, the small particles of carbon that have been deposited on the point of the electrode form a hard scale when cool. When the dynamo is again started this scale will offer a resistance too great for the weak current present in the dynamo to overcome. Therefore, the point of the electrode should be cleaned off at the end of each trip. When the dynamo is started the points of the carbon and the electrode must be in contact or no current can be established, and it will be impossible for the dynamo to build up.

The thumbscrew 81-a (Fig. 155) in copper electrode holder 200 should be slackened off from the electrode, and the electrode removed from its holder on each trip. Any scale which has formed around the electrode should be removed. Otherwise in a very short time the deposit of scale will become so heavy that it will entirely insulate the electrode from its holder, causing a break in the circuit, and it will be impossible to get a light, no matter how clean the point of the electrode may be.

Adjusting Spring and Magnet. There is but one regulating or adjusting spring 93 (Fig. 155) to this lamp. Its duties are two-fold: (1) It brings the levers 59 and 60, clutch rod weight 78-a, clutch rod 78-b and clutch 44 into such a position that the carbon by its own weight is dropped down until it comes in contact with the point of

the electrode. (2) It prevents solenoid 65 from pulling the iron armature or magnet down far enough to separate the carbons to such an extent as to break the circuit and cause the light to go out.

The iron armature or magnet is connected to the magnet yoke 90, which in turn is connected to levers 59

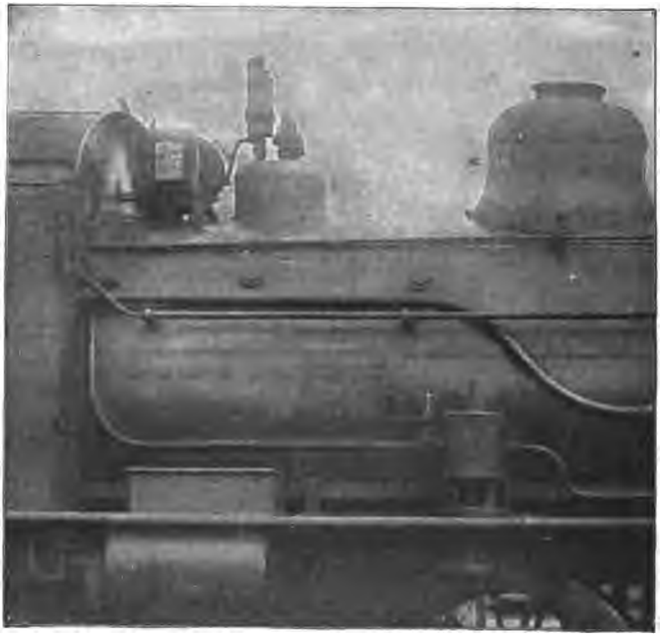

Fig. 158.

and 60, clutch rod weight 78-a, clutch rod 78-b and clutch 44 in such a manner that a downward movement of magnet 64 would raise the clutch weight, clutch rod and the point of the clutch, moving the carbon away from the copper electrode and establishing the arc and light. The regulating spring 93 might be termed a governor to the action of the solenoid. This is one of the duties

it performs, as the spring is secured to the opposite end of lever 60 from that to which the magnet is connected and pulls.

The volume of light is dependent largely upon the regulation of the tension spring. Track conditions and the jar and vibration of the locomotive exert a marked influence upon this spring and incidentally upon the light. Where track conditions are poor, this spring should be run as loose as possible without causing the light to go out when the locomotive is in motion. If the tension of this spring is too weak, when the engine is brought to a stop, and the jar and vibration are no longer present to assist the weak spring to pull against the stronger magnetic influence of the solenoid which is pulling down on the levers and up on the carbon, the solenoid will separate the carbon points so far that the current can no longer flow across the intervening air space and the circuit will be broken. The instant the circuit is broken, the strength of the solenoid is dissipated and the adjusting spring 93 brings the levers down in such a position that the carbon can again drop to the electrode. When the carbon comes in contact with the electrode, the circuit is again established and the light will come up, only to go out almost as quickly as it appeared, for the carbon will again be drawn so far away from the electrode that the circuit will again be broken. This process will be repeated until the locomotive is again in motion, or the tension of the regulating spring is increased.

If the tension of the regulating spring is too strong, the solenoid cannot exert sufficient pull on the levers to overcome the pull of the spring and separate the carbon so that an arc can be formed. Or, the spring may be so adjusted that when the locomotive is at rest, the light will burn brightly, but when the speed of the engine

reaches a certain point, the light becomes dim and will go almost if not entirely out. This action is due to the fact that the high speed of the locomotive increases its vibration, which tends to give the regulating spring greater tension, or pull, against the action of the solenoid, and causes the clutch to relax its hold on the carbon, which will then drop downward. The moment the speed is reduced, however, the light will again come up to a satisfactory brilliance, for the pull of the regulating spring will not be so great, and the magnet will be strong enough to hold the levers down and the carbon up.

The tension or adjustment of the regulating spring is correct when it is adjusted as loosely as possible without allowing the light to go out when the locomotive is at rest. In other words, the spring should be so adjusted that the light will flicker or flash a little when the locomotive is at a standstill. All the light possible from a given speed of the armature is then being secured, and when the engine is in motion the light will be bright and steady. When spring 93 is once properly adjusted, which is easily and quickly done, there is never any occasion for changing the adjustment. If the lamp fails at any time, the trouble will not be found in the spring.

Top Clutch Spring. A small spring 92 is concealed within a recess of the top carbon holder 300. The duty of this spring is to hold the heel of clutch 44 down, which it accomplishes with the aid of clutch foot 102 and clutch foot rod 102A, and renders it possible for the clutch to grip and raise the carbon from the point of the copper electrode and so maintain the arc. If the tension of this spring is too weak, when the locomotive attains a high speed, this spring will be unable to hold the heel of clutch 44 down in position, and it will be jarred up, releasing the carbon, as the magnet yoke 90 will travel downward and strike the small lug on lamp column

51½. The magnet will then be unable to keep the point of the clutch higher than its heel, the carbon will fall to the electrode and the light will go out. In this case, however, the circuit would not be broken.

The strength of the solenoid will be greater for the reason that there is a greater amount of current circulating in the coils, since there is no resistance offered to the flow of current at the lamp. As resistance is necessary to the production of the arc and light, neither will be produced, as the magnet will still be pulling down on the levers, which in turn cannot release the clutch so that it can grip and raise the carbon. When the speed of the locomotive is reduced, this little spring will force the heel of the clutch down a short distance, when the clutch will hold the carbon against the point of the electrode until the current is shut off, when the levers will adjust themselves to a normal position. If the mechanism acts in the manner described, the steam should be shut off from the turbine wheel until the proper adjustment can be made, or damage may result. If the equipment is operated for any length of time with a weak spring and in the manner just described, the coils will become heated, the insulation will become charred and useless, and the result will be a burned out armature or field coil.

This trouble can be prevented by the exercise of a little care and forethought on the part of the engineman. The carbons should burn between eight and nine hours, and if they feed too freely it will be caused by the weakness of spring 92-a, or by the edges of the clutch becoming worn smooth and round, when they should be sharp. Either of these defects will produce the conditions described, and they can easily be prevented, as an inspection made once in six months, or even once a year, will prevent them. A very large percentage of electric

headlight failures is due to carelessness in trimming the lamp and in putting in new carbons.

A headlight failure sometimes occurs, when the speed of the locomotive is reduced or it is brought to a stop. At such times the engineman may have opened the door of the headlight and jarred the light with his hand, whereupon the light instantly comes up, giving the impression that the defect had been remedied, which it had been temporarily. In jarring the lamp, the carbon had been jarred down through the clutch to the point of the electrode, re-establishing the circuit, which was just what the locomotive did when in motion. There is no assurance, however, that, when the magnet becomes weak enough to release the clutch again, it will not catch or hang up in the clutch as before. When an arc is formed and the carbon burns away, the greater the length of the arc, the less current passes from the carbon to the electrode, and the corresponding amount circulating in the solenoid tends to weaken the magnetic pull on the levers and clutch, which holds the carbon. When the arc attains a certain length the current in the solenoid becomes weak enough to release the levers and clutch, and the carbon feeds down or falls by its own weight.

Carbons. Carbons are molded or forced and sometimes they are not absolutely round or true, although they are supposed to be tested before leaving the factory, by being passed through a templet, so that they will fall or feed through the clutch in any position. If the carbon is rough, or irregular in shape, it will be held up in the clutch so far away from the electrode that the current cannot flow across the intervening space and the circuit will be broken.

When new carbons are applied they should be passed through the clutch to determine whether they are true, or are likely to hang up in the clutch. This can be done

by loosening thumbscrew 79, removing carbon holder 300 from the lamp, just as is done when preparing to remove the reflector and lamp from the cage, placing the carbon in the carbon clamp, securing the top holder by stud for thumb nut 79, then returning the carbon and clamp to the holder, releasing the carbon and noting whether it will fall entirely through the clutch by gravity. If the carbon will not pass through freely, it should be turned until a position is found in the clamp in which it will do so.

The light failures referred to, which occur when the locomotive is being brought to a stop, are in nearly every case due to improper fitting of the carbon. However, the same trouble will be experienced if the tension of spring 93 is too weak, but this seldom happens, as enginemen generally run this spring too tight rather than too loose.

Small Contact Brush. There are small copper contact brushes secured to number 88 of the carbon clamp (Fig. 155). The duties of this carbon clamp are to hold and guide the carbon down and transmit the current to the carbon by its contact with the guide bar, or upper carbon holder 100, through the medium of the small contact brushes. These contact brushes must not bear too heavily against holder 100, or the carbon will not feed down when the locomotive is at rest. It requires an imperfect contact to create an arc, and the carbon clamp cannot be made to fit closely enough to the guide bar of the upper carbon holder, and at the same time allow the carbon to feed down. Therefore, if the contact brushes do not touch upper holder 100 when the locomotive is in motion, there will be no constant and perfect contact between the carbon clamp and the upper holder, the light will flicker and flash, and the guide bar to the

upper carbon holder and the flange to the carbon clamp will be fused.

Loose Binding Screws. If the equipment has been operating properly and giving a satisfactory light and suddenly the light begins to flash, it will be found that one of the binding screws 68 is loose, and is not holding the wire firmly to the binding post.

LIGHT FAILURES.

No doubt many light failures have resulted in the past from the fusing of the copper electrode and holders, and engines have been run over an entire division with a lantern hung in front, because the engineman thought that there was no temporary remedy for the trouble. This fusing takes place very often while the engine is in the hands of the hostler, for there are few enginemen who do not recognize the cause of the trouble when a shaft of green light is thrown from the headlight instead of the usual white light, and who would not reduce the speed of the generator immediately by throttling the steam.

When this difficulty is experienced it is not necessary to dispense with the headlight for the trip, for only the lower or negative point and its holder have been destroyed. All that is necessary to put the lamp in service is to remove the damaged electrode holder from bottom clamp 53, and substitute an ordinary iron bolt, securing it in the clamp by tightening up screw 68, just as is done with the electrode holder. One end of the bolt should come as high as the center of the reflector, and the other end must not be allowed to come in contact with the base of the lamp.

The fusing of the electrode and holder is caused by a high electromotive force or voltage, and this will also cause the improvised negative point to fuse if the speed of the armature is not controlled by throttling. However,

as copper fuses at 1,996 degrees Fahrenheit and iron at 2,786 degrees Fahrenheit, the iron bolt can withstand a higher temperature than the copper electrode, although it is not as good a conductor of electric current as the copper.

In an emergency of this kind a carbon can be used, by securing it to the bottom clamp as already explained. A bolt is preferable, however, as the lower carbon will be constantly burning away, though only about half as fast as the upper one. As it is impossible to set the lower carbon exactly under the top one, the arc will be constantly lowered in the reflector, sending the shaft of light upward so that it will not touch the track, and in a short time the lower carbon will burn down until the top one will drop past the lower carbon point, resulting in a light failure. If it is necessary to use a carbon for the negative point, the lower carbon should be raised to the height of the center of the reflector about once each hour the light is in use, in order to derive full benefit from it.

The point of the carbon must be set exactly over the point of the copper electrode in order to secure a good arc. The electrode and holder can be bent in any direction necessary to cause them to line up properly with the carbon. The holder is of brass, which can easily be bent without danger of breakage.

Shaping the Point of the Electrode. The copper electrode should be shaped up with about one-eighth of an inch surface on its point, for the reason that electricity spreads itself evenly over the surface of the conductor through which it is passing, and if there were a one-half inch point on the electrode a thin, flat arc would be produced, instead of the long one, as when the copper is pointed properly.

CARE OF DYNAMO AND ENGINE.

The dynamo and turbine are durable and the cost of maintenance is very small. There are but four parts that can wear out, viz., the governor valves, the two bearings, and the commutator. The shaft is made of steel, which is hardened and then ground, and, if properly lubricated, the wear at the journals takes place in the boxes. The bushings can be easily and quickly removed and replaced when worn out, without removing the equipment from the locomotive. The commutator, if run without sparking, will last for several years, and if provided with the new style brush holders with fixed tension, should wear indefinitely.

A large percentage of the difficulties that are experienced with the dynamo can be prevented by the exercise of care and forethought on the part of the engineman. A general knowledge of the conditions met with in the operation of the dynamo will enable him to overcome nearly all of the troubles that may be experienced.

When the light fails, the dynamo should not be run for any length of time, as great damage might result, such as the burning out of the armature or the field coils.

CAUSES OF AND REMEDIES FOR DEFECTS.

The most common cause of trouble is short circuits in the wires; consequently when an equipment is applied or rewired care should be exercised to see that the wires are protected. A short circuit does not literally mean that the current is passing over a shorter distance to return to the dynamo, but that it is passing through a path of less resistance. Short circuits sometimes occur in the cab wires and at other times in the main wires that lead to the lamp. They are brought about by the insulation wearing off and the exposed wires coming in

contact with each other, either directly or through the medium of a bolt, hand railing or other conducting material. If the insulation is worn from one wire and the wire is allowed to come in contact with some metallic substance, there will be a leak or ground, but if the insulation is worn from both wires and they are brought in contact, a short circuit will result. When a short circuit is established it is easier for the current to pass through it and return to the dynamo, than to pass through the lamp where it would meet with resistance, which is essential in order to produce the arc or light.

Sometimes one of the main wires will break or the carbon will stick in the clutch, and in either case the circuit will be broken. With the engine running at a high rate of speed, if it is impossible for the engineman to locate the trouble immediately, in order to prevent further trouble he should shut off the supply of steam to the turbine and stop the dynamo. The trouble can usually be located at the next stopping point, and the light again put in service.

If the time is limited at the next stopping point, the engineman should start the turbine engine with about the same throttle opening as when operating the lamp, and then pass to the dynamo and note whether it is running rapidly and lightly, with little noise, or is running slowly, laboring heavily, and making a great deal of noise. If the former condition is noted, the wires are not connected up or are broken, and in any event there is an open circuit. To ascertain quickly where the trouble is the dynamo should be tested by placing a carbon or piece of steel across the two binding posts 28 and 29 (Fig. 150). If there is no flash at these posts the trouble is in the dynamo, and it is unlikely that the engineman can make the necessary repairs. It may happen, however, that one of the field connections is

loose and if this is the case the trouble can be repaired by tightening the loose screw.

If there is a flash when the carbon or steel is placed across the dynamo binding posts the dynamo is all right, and the break is further toward the lamp. The carbon should next be placed across the two binding posts at the lamp, and if no flash results, the trouble is between the lamp and the dynamo, and is due to one of the wires being broken. To repair this, the insulation should be stripped from the ends of the broken wire, and the two naked ends securely twisted together. This connection should then be wrapped with any material that will insulate the wire. A handkerchief will answer the purpose. If a flash is produced at the lamp when the carbon is placed across the binding posts, the trouble is in the lamp, where, upon investigation, it will be found that the carbon and copper electrode are not in contact. They may be separated by scale which has formed on the point of the electrode, the carbon may not be of sufficient length to touch the electrode, the carbon may be held up in the clutch by reason of its own imperfections and irregular contour, or a scale may have formed around the electrode in such a manner as to insulate it from its holder. These causes suggest their own remedies.

On the other hand, if the dynamo is running very slowly, laboring heavily and making a great deal of noise, it indicates a short circuit in the lighting system. To locate the trouble one of the main wires should be removed from the binding post at the dynamo; if the dynamo still runs slowly and there is a cab circuit, one of the cab wires should be disconnected. If the speed of the dynamo instantly increases, the trouble is in the cab circuit and the main wire should be returned to the binding post, while the cab wires must remain disconnected until the engineman has time to locate the trouble. This

will again put the headlight in service. If, however, when the cab wire is disconnected, the speed of the dynamo does not increase, the trouble is probably caused by one or both of the governor valves of the turbine engine being stuck partly, if not entirely shut. If one or both of the governor plungers are responsible for this failure and slow speed, there will be but a small amount of steam escaping from the exhaust pipe of the turbine engine. If the trouble is not found in the engine, it is in the dynamo, in which event it will probably be necessary to finish the run without the use of the headlight. Dynamo defects can be repaired only at the shops.

If the trouble is caused by the sticking of the governor plungers or valves, they can be released by tapping the outside of the casting with a hammer, or by removing the top plug in the engine casting and introducing a little coal oil or black oil at this point. When steam is again admitted to the turbine wheel, this oil will be blown against the face of the governor plungers, and may release them by cutting away the scale which has caused them to stick.

If the speed instantly increases when the wire is removed from the dynamo binding post, the trouble is not in the dynamo, engine, or cab circuit, but further toward the lamp, and the wire should be returned to its binding post. One of the wires should then be removed from its binding post at the lamp, and if the speed of the dynamo does not instantly increase, the short circuit will be found in the wires leading from the dynamo to the lamp. All that is necessary is to find the exposed wire and to wrap it with insulating material, thus forcing the current to pass through the lamp instead of following this short path to the dynamo.

If, when the wire is removed from the lamp binding post, the speed of the dynamo instantly increases, the

trouble is not between the dynamo and the lamp, but in the lamp itself, where it will probably be found that thumb nut 79 has not been tightened securely and has allowed the point of the carbon to pass the point of the copper electrode, or that the carbon is stuck fast in the clutch and against the electrode. In either case the trouble can be remedied by straightening up the carbon and tightening thumb nut 79, and also noting whether the carbon will raise and fall freely through clutch 44 to the point of the electrode.

A "short" can occur in insulation 96 at both top and bottom brackets, in insulation washer 97 at the binding posts, or in the insulation bushings around the binding posts, where the posts go through the lug on the lamp column. These insulations never give way, however, so that a short circuit will never occur at these points unless some workman has taken the lamp to pieces and failed to return all insulations when re-assembling the parts. All of the difficulties described can be avoided, if proper care is exercised when the wiring is done.

FOCUS OF THE LAMP.

The efficiency of an electric headlight equipment is dependent largely upon the focus of the lamp and the condition of the reflector. When the arc is formed, or, in other words, when the lamp is burning, the dynamo and lamp are performing their full duties.

The cage or case must be set level, and parallel with the boiler, and the reflector must be set so that its front edge or face is parallel with the front edge of the cage, in order that the light rays may be properly collected and thrown on the center of the track.

To focus the light properly, the locomotive should be placed at one end of a level piece of track, not less than half a mile in length. The lamp is adjustable and can be

moved in all directions, and it should be moved until the shaft of light is thrown upon the track in such a manner as to secure the best results. The light should be reflected in parallel rays, and in as small a space as possible.

It is impossible to get the full volume of light if the lamp is not focused and the reflector is dirty. Even with the best and brightest of reflectors, a certain percentage of the light rays is absorbed by the reflecting surface, and this absorption of light is greatly increased by a dirty or dim reflector. It is essential, therefore, that the reflector be kept clean and highly polished at all times in order to insure the best results.

HOW TO FOCUS THE LAMP.

The most satisfactory method of focusing the lamp is on a straight piece of track, proceeding in the manner before described, as the cage does not always set straight and level on the arch, and the best angle for the shaft of light can be obtained by shifting the reflector. When this is impossible the lamp can be focused by measurement in the following manner:

The engineman must first see that the reflector case sets straight and level on the arch of the locomotive and that the front edge of the reflector is parallel with the front edge of the case. The center of the top of the copper electrode must be placed in the center of the reflector and the measurements taken from the top of the electrode to the sides, top and bottom of the reflector. When the exact center has been found, the electrode should be lowered one-eighth of an inch.

If the reflector has a sixteen-inch face and is eight inches deep, the copper electrode should be placed two and three-eighths inches from the back of the reflector. If the reflector has an eighteen-inch face and is nine

inches deep, the electrode should be placed two and one-fourth inches from the back of the reflector, and if the reflector is eighteen-inch face and is twelve inches deep, the electrode must be placed one and three-fourths inches from the back of the reflector.

GENERAL INFORMATION.

The electric headlight equipment was designed to meet the requirements of severe locomotive practice, but it is not self-adjusting or automatic in its operation. It is simple and easily understood, however, and if given a few moments of attention each day will give a satisfactory light.

The commutator is the vital part of the machine and must be kept clean in order to insure good brushes, and the correct spring pressure must be maintained upon the brushes.

In starting the dynamo the steam should be turned on slowly and the water of condensation allowed to pass out of the pipes and turbine. The speed of the turbine and armature should not exceed that necessary to produce a good light.

There is no danger of receiving a severe or dangerous shock from the electric headlight apparatus, as the resistance of the human body is too great for the low voltage employed to force a current through, and an engineman need have no fear of handling the wires and the dynamo when the apparatus is in operation.

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